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Abstract

Fertilizer and other input subsidies have been a prominent component of agricultural policies in many Asian and African countries since the 1960s. Their economic and political rationale is scrutinized with emphasis on the second generation of targeted input subsidy programs that were scaled up in Sub-Saharan Africa (SSA) after 2005. The extent to which they full-fill the goal of being 'market smart' is assessed after inspecting the potential for such subsidies in SSA. The new fertilizer subsidy programs do not live up the market smart principles and suffer from severe design and implementation failures. While a clear exit strategy was one of the key principles, this principle has been neglected with the result that most current programs are more 'sticky' than 'smart'. They have only partially achieved the intended impacts and have resulted in a number of unintended negative impacts. Redesign should start from a pilot stage testing basic mechanisms.

Key words: Fertilizer subsidy, externality, market failure, market smart, impact, elite capture.

JEL codes: Q12, Q18, Q28.

1. Introduction

This is a review of the economics of fertilizer subsidies. Fertilizer subsidies are popular among politicians and the rural public in many developing countries while they are highly controversial among economists, development agents and policy analysts. The use of fertilizer subsidies has therefore been subject to a large number of studies across the developing world over the last 50-60 years since they were introduced the first time about 60 years ago in several Asian countries as part of the Asian Green Revolution (Hazell 2010).

There have been a number of comprehensive reviews of the impacts and economics of fertilizer subsidies, including some recent reviews in the African context. An overview of these reviews is given initially to clarify how this review complements and adds to existing reviews. This review aims to be broader in terms of discussing the underlying theoretical ideas, the historical time horizon, and the geographical coverage than the most recent reviews that have concentrated on the more recent experiences with fertilizer subsidies in sub-Saharan Africa (SSA). The hope of the author is that this can stimulate critical thinking about how agricultural policies in especially SSA can enhance more sustainable agricultural intensification. The continuing high population growth in rural areas in SSA contributes to land fragmentation into smaller and smaller farms but also to deforestation at the extensive margin while the tightening land constraint pushes towards a stronger need for land use intensification in a growing number of countries (Chamberlin et al. 2014). Low fertilizer use levels have been seen as a fundamental problem associated with low and stagnant crop yields hindering agricultural development in SSA (Sanchez et al. 2007). Crawford et al. (2006), in their review for the World Bank, reported average fertilizer rates as low as 9 kg/ha in Sub-Saharan Africa, while disappearing fallows, high levels of deforestation, land degradation and nutrient depletion indicated non-sustainable land use (environmental externalities). Climate change and the need to reduce emissions from agriculture also point towards a need for intensification rather than area expansion to meet the food needs of future generations in SSA. Tilman et al. (2011) has estimated that the carbon emissions from a production increase through area expansion are about three times as high as a production increase through intensification and higher fertilizer use, while ensuring fertilizer use efficiency is a necessary part of this. The potential future role of fertilizer subsidies in achieving this is therefore up to debate.

It is essential to see the economics of fertilizer subsidies in relation to the fundamental production relations in tropical agriculture. These relations are nicely characterized by Binswanger and Rosenzweig (1986); a) the dominance of rain-fed agriculture with strict seasonality constraints in land preparation, input use and harvesting, making agricultural input and output markets highly seasonal; b) the immobility and spatial dispersion of land enforcing spatially dispersed production; c) poor infrastructure and high transportation costs in geographically dispersed and thin seasonal markets affecting the reach and competitiveness of input and output markets; d) covariate risks linking spatially correlated production risks with market price variations and market risks; e) moral hazard and adverse selection associated with information asymmetries affecting the degree of (mal-)functioning of all markets and especially labor, credit and insurance markets. Investments in infrastructure and irrigation can alleviate some of these constraints, and with the information technology revolution, the costs of obtaining information and communication have been dramatically reduced. These developments have also contributed to the start of a rural transformation process in a growing number of developing countries including in SSA. Such processes are strengthened by stimulating private sector development through training of rural retailers and agro-dealers and build-up of producer organizations, broader investments in value chain development from contract farming to supermarket development. Nevertheless, the fundamental production relations identified by Binswanger and Rosenzweig (1986) imply that rural factor market imperfections continue to condition the rural transformation processes and the way sustainable agricultural intensification can be facilitated, including the extent of fertilizer use and whether and how fertilizer subsidies play a role (Sheahan and Barrett 2017; Gollin and Udry 2017).

We may divide the past fertilizer programs roughly in the first and second generation of subsidy programs:

1. Generation: Universal input subsidy programs: In the 1960s and 70s international donors supported the used of universal input subsidies to overcome market failures in input and finance markets. The general lesson from use of such subsidies in the African context was that they were ineffective in achieving their stated objectives (Morris et al. 2007; Jayne and Rashid 2013). With the debt crises that many African countries faced in the 1980s subsidy programs were scaled down or eliminated as part of the stabilization and structural adjustment programs that were put in place to get the indebted countries out of the crisis. The general fertilizer subsidies were therefore eliminated in most of the African countries.
2. Generation: The market smart and targeted subsidy programs: The new wave of programs after 2005 was triggered by the Malawian example which gave new hopes for an African Green Revolution (Sanches et al. 2007; 2009; Denning 2009). It also triggered rethinking in the World Bank and the development community in general that market-smart subsidy programs may work (World Bank 2007; Morris et al. 2007). By 2010 at least 10 African countries accounting for at least half the population in SSA had adopted such programs costing 0.6-1.0 billion US$ per year and representing 14-26% of public expenditures on agriculture in these countries (Jayne et al. 2018). High international food prices and recovery after the debt crisis in many African countries through debt forgiveness also reduced the focus on conditionality among international

donors (Jayne and Rashid 2013). This gave more political freedom to political leaders, who were competing to win local elections, to offer subsidies to “buy” votes.

This review goes through the theoretical foundations and economic and political reasons that have been and could be used to argue for the use of fertilizer subsidies. These will be contrasted with the characteristics of the production relations in the economies where such subsidies have been introduced. This is used as a basis for discussing the potential for market smart subsidies in SSA including agro-ecological, behavioral and institutional constraints and opportunities. Typical design and implementation failures are then outlined. Impact studies are then reviewed including assessments of intended and unintended impacts from fertilizer subsidy programs. Finally, I review studies of economic returns to fertilizer subsidy programs before I conclude.

2. Overview of earlier reviews

Fertilizer subsidies have received a lot of attention and have been subject to several reviews including other recent reviews. I provide an overview of these reviews, how they differ in objectives and coverage and clarify how this review adds to the literature compared to these other reviews.

Fertilizer use in African agriculture (Morris et al. 2007) is a broad review of alternative policies including fertilizer subsidies to enhance fertilizer use in Africa. The study takes a broad and pragmatic view of pros and cons of alternative approaches to stimulate fertilizer use where fertilizer subsidies is one possible element of more comprehensive policies. They introduce the concept “market-smart subsidies” and discuss the requirements for such subsidies.

Jayne and Rashid (2013) provide a synthesis of recent evidence (after 2005) on input subsidy programs in SSA. They focus in particular on the characteristics of beneficiaries, crop response rates to fertilizer applications and the implications for the performance of subsidy programs, the impact on national fertilizer use, input distribution systems, food prices and poverty rates. They contrast the returns to fertilizer subsidies with returns to other research and development and infrastructure investments.

Gautam (2015) reviews main arguments for and against agricultural subsidies and provides a selective review of empirical findings, primarily in Asia. Fertilizer subsidies is only one type of agricultural subsidies and the review assesses the relative size of fertilizer subsidies versus other types of agricultural subsidies such as power subsidies, irrigation subsidies and credit subsidies and the effects of these subsidies with examples from India, Sri Lanka, and China. He concludes that most of these Asian subsidy schemes, which in the case of fertilizer subsidies have been of the universal subsidy type, have had distortionary effects due to design and implementation failures.

Jayne et al. (2018) takes stock of the second-generation of agricultural input subsidy programs in SSA with regard to the performance of these programs. They synthesize 80 studies in seven countries (Ethiopia, Ghana, Kenya, Malawi, Nigeria, Tanzania and Zambia). In particular, they assess the impacts on total fertilizer use, food production, commercial input distribution systems, food prices, wages and poverty.

Heming et al. (2018) make a systematic review of agricultural input subsidies for improving productivity, farm income, consumer welfare and wider growth in low- and lower-middle income countries. The review covers studies up to 2013. From an initial review of 4480 unique studies, they found 1120 with relevant outcomes and narrowed these down to 31 high quality studies, of which 15 were experimental/quasi-experimental and 16 modelling studies that use computable models to simulate the effects of agricultural input subsidies on measures of consumer welfare and wider growth. Only four of the 31 studies were in Asia and the rest in SSA. In SSA, 15 were in Malawi, showing the high interest in that program, three in Zambia, two in Ethiopia and Tanzania, only one study in each of Ghana, Madagascar, Mali, Mozambique, and Nigeria.

This study aims to complement these studies by inspecting more thoroughly some of the theoretical foundations of input subsidy programs, their limitations and implications for future agricultural policies with emphasis on the SSA context.

3. Theoretical foundations for fertilizer subsidies

3.1. The origin of fertilizer subsidies and their economic rationale

The concept external economies originates from Alfred Marshall (1890; 1920) who associated this with increasing returns to scale. Pigou (1924) helped to refine this idea stating that competitive industries enjoying external economies or downward sloping supply curves produce less than optimal levels of output. The market forces can in such a situation not be relied upon to ensure optimal resource allocation and government subsidies would be required to expand output towards an optimal level. On the other hand, increasing cost industries in a dynamic sense produce too much. It would, according to Pigou, be optimal to tax the increasing cost industries and use this tax to subsidize the decreasing cost industries. This is the origin of the idea that Pigouvian taxes and subsidies may be used to internalize externalities (external economies).

Since then the concept external economy or externality has been loaded with many different phenomena including emptiness (Papandreou 1998). The most relevant phenomena or concepts used to argue for fertilizer subsidies include:

a) *Externality.* There is a huge literature in economics loading 'externality' with different meanings including phenomenological and general equilibrium perspectives. One of the most known definitions is that of Baumol and Oates (1975): when an activity of one person affects the utility of another person (positively or negatively) without the first person facing any cost or compensation for the effect on the other. To relate it to fertilizer use, we can think of pollution or soil acidification as negative externalities and build-up or replacement of lost nutrients as positive externality. A tax may be appropriate to reduce the first type of externality and a subsidy could stimulate the fertilizer use and thereby reduce the nutrient depletion in the second case. It may, however, be less obvious that the latter represents an externality given the definition above as a farmer, who depletes his own land by not replacing lost nutrients, he is the one (or his children) who will also pay the cost in the future. In the broader sense, if an amount of food can be produced on a small piece of land by using more fertilizer rather than by cutting down trees to expand the area with less use of fertilizer, intensive farming with fertilizer may reduce the global externality associated with deforestation.
b) *Market failure.* Bator (1958) equate externality with market failure and associate this with Pareto-inefficiency and attempt to find causes for these. Arrow (1969) sees externalties as a subset of market failure and market failure as synonymous with non-existence of markets. He also relate market failure with transaction costs as the case where transaction costs are so high that the market no longer is worthwhile. A more comprehensive integration of the concepts of transaction costs and Pareto-efficiency are given by Greenwald and Stiglitz (1986) in their assessment of externalties in economies with imperfect information and incomplete markets. They define constrained Pareto-efficiency and conclude that economies with such characteristics rarely are constrained Pareto efficient, implying that there can often be room for interventions that can improve efficiency. Externalties may potentially be associated

with large multiplier effects. Fertilizer subsidies were initially introduced from the perspective of missing and imperfect markets as part of the Green Revolution in Asia.

c) *New technologies and learning effects.* The Asian Green Revolution focused on the development and dissemination of new and more productive agricultural technologies and fertilizer subsidies was part of the technology package to enhance the adoption of such technologies by speeding up the exposure and thereby learing. This improved the availability of new technologies and made them more affordable to poor farmers. The induced technological and institutional innovation approach was very efficient in stimulating rural development and gave high returns through the 1960s and 70s in Asia (Ruttan and Hayami 1984; Hazell 2010).

d) *Poverty trap.* The argument that low fertilizer use, poverty and vulnerability represents a poverty trap that needs to be overcome through massive investments is associated with the literature on poverty traps, the Millennium Village project, and the sharp upscaling of the input subsidy program in Malawi in 2005 (Sachs 2005; Carter and Barrett 2006; Sanchez et al. 2007; 2009; Denning et al. 2009). This argument has been important for mobilizing funds for breaking the poverty trap including funds for fertilizer subsidies in Africa.

e) *Recovering after droughts and food shortages.* Upscaling of fertilizer subsidies has been a response in some countries, such as Malawi, to rapidly recover from such shocks by increasing local food production to reduce the need to import foods and re-establish national food self-sufficiency (Dorward and Chirwa 2011). Levy (2005) calculate that the Starter Pack in Malawi costed less than a third of the cost would have been to import the same amount of food as was generated by the program. Morris et al. (2007) emphasize that it is in cases where fertilizer and food markets function poorly that fertilizer subsidies can be used as a safety net for the poor. However, this also critically depends on the targeting efficiency in terms of reaching the poor and food-deficient households, the fertilizer use efficiency, and the relative cost-efficiency of the program.

f) *Market smart subsidies.* This concept is elaborated in Morris et al. (2007) and in the World Bank World Development Report 2008 (World Bank 2007). The requirements for fertilizer subsidies to be called market smart included that they should a) stimulate new demand without displacing existing commercial sales, b) encourage competition in the fertilizer distribution channels, and c) be temporary and with a clear exit strategy (World Bank 2007, p.152). Morris et al. (2007) furthermore emphasized that the subsidy has to be part of a wider strategy providing complementary inputs, strengthened output markets and has a proper sequencing of interventions. Following a strong tradition in economics, they also emphasized that fertilizer use had to be economically efficient. As a tenth point, they add that equity considerations matter and pro-poor growth could be aimed for, as long as nine other principles are satisfied (Morris et al. 2007, p. 104). However, they add that poverty reduction or food security objectives may be given precedence over efficiency and sustainability goals if it can be determined that fertilizer interventions are a cost-effective way of addressing these problems. This is clearly in line with the market failure argument for use of subsidies where there could be efficiency gains from stimulating demand, market development and utilization of economies of scale and complementarities between technologies and markets by reducing transaction costs, organization costs and information asymmetries. The tools proposed to achieve this are demonstration packs, input vouchers, matching grants and partial loan guarantees. This new thinking on subsidies contributed to the further scaling up of input subsidy programs in SSA after the initial perceived success in Malawi (Denning et al. 2009).

g) *Fertilizer subsidies as a political instrument.* It is important to understand the political economy of fertilizer subsidies. They have typically been introduced or scaled up at critical points in time such as after droughts and have for that reason been popular among those who have benefitted. At the same time, their popularity among broad segments of the population has made it very difficult for those in power to implement an exit strategy without committing political suicide. Even scaling down of input subsidy programs can affect election outcomes (Gautam 2014). Another reason for the "stickiness" if input subsidy programs is their potential for rent-seeking (Holden and Lunduka 2013; Jayne et al. 2015). Such rent-seeking behavior can lead to leakages (diversion) and severe targeting errors that undermine the officially intended objectives and targeting efficiency. Political considerations and rent-seeking behaviors may also undermine the extent to which market smart characteristics are taken into account in the design as well as the implementation of programs. Political factors and the fact that many stakeholder groups attempt to influence the design and implementation of such programs may also lead to unclear and contradictory objectives as well as implementation strategies over time due to competing interests. The potential outcome is very costly and inefficient programs that crowd out investments that could have yielded much higher long-term returns (Jayne et al. 2013; 2018).

From this brief review of the arguments for use of input subsidies and particularly fertilizer subsidies it is evident that market failures and recovery after droughts causing food shortages have been the primary arguments for scaling up such subsidy programs. It is also evident that here is a tension between short-term needs and longer-term benefits on one hand and between those in need and those with political power on the other. At the same time, those in power depend on the political support from those in need. This results in emphasis on short- rather than long-term objectives such as sustainable intensification and economic growth. The fertilizer subsidy programs therefore potentially threaten to re-enforce the poverty trap rather than break it. However, the consequent economic and political crisis may also potentially lend itself to the opportunities for redesign of better policies.

4. How big is the potential for market smart fertilizer subsidies in SSA?

Fertilizer use levels have been much lower in SSA than in other parts of the world and this has been associated with failed agricultural development (Morris et al. 2007). However, a recent examination of World Bank LSMS data from six countries shows large variation in fertilizer use across countries. Some countries which use fertilizer subsidies (Ethiopia, Malawi, Nigeria) also have much higher levels of fertilizer use (Sheahan and Barrett 2017). While Crawford et al. (2006) reported an average fertilizer use rate of 9 kg/ha in SSA, Sheahan and Barrett (2017) report rates of 45, 146 and 128 kg/ha for these three countries. Zhang et al. (2015) emphasize the central role of nitrogen (N) to facilitate sustainable intensification and that large parts of SSA still face an undersupply of N that prevents intensification while there is at the same time a strong need to increase yields to reduce area expansion. Does this mean that one should advocate for introduction of fertilizer subsidies in more countries in SSA where fertilizer use rates still are low? And can temporary use of fertilizer subsidies lead to sustained use of higher levels of fertilizer? This requires a careful examination of the reasons for low fertilizer use and whether these represent market failures or externalities that can be cost-effectively removed.

4.1. Profitability of fertilizer use

Some studies have found that fertilizer adoption is low even when fertilizer use is profitable (Duflo et al. 2011; Holden and Lunduka 2014; Koussoubé and Nauges 2017). However, there is also evidence that under current input and output prices fertilizer use is only marginally profitable many places due to low soil fertility, soil acidity, low organic matter content and continuing land degradation, high erosion levels and nutrient mining associated with existing land use practices, and poor market access contributing to high farm gate input prices and low farm gate output prices (Marenya and Barrett 2009 (Kenya); Sheahan et al. 2013 (Kenya); Liverpool-Tasie et al. 2017 (Nigeria); Burke et al. 2017 (Zambia); Minten et al. 2013 (Ethiopia), see Jayne et al. 2018 for a more detailed summary). This leads to low value-cost ratios (VCR) and reluctance to purchase fertilizer at commercial prices (Jayne et al. 2018). However, relative input and output prices may change rapidly and vary locally and this may imply that higher fertilizer use levels could be profitable especially with the introduction of new and better varieties and improved infrastructure. However, this does not mean that fertilizer subsidies represent the optimal solution, rather investment in infrastructure and market development can give higher and more lasting impacts.

4.2. Soil quality and sustainable intensification

If soil degradation causes low profitability of fertilizer use, can investment in soil conservation and other land management practices also enhance the profitability of fertilizer use and thereby increase demand? And can fertilizer subsidies potentially be used to enhance intensification and conservation incentives?

Acidic soils such as oxisols and ultisols are widespread in the humid and subhumid tropics and are estimated to cover 43% of tropical soils such as savannas and tropical forests (Sanchez and Salinas 1981). Their low soil fertility and poor infrastructure have protected them from cultivation but the pressure is increasing with population growth and infrastructure development. Expansion of cropping areas and shortening of fallow periods is associated with increasing deforestation (Holden 1993). Introduction of pan-territorial prices and input subsidies for maize production resulted in reduced deforestation and rapid expansion of maize production in Zambia from the late 1970s (Holden 1991). However, the following removal of these transportation and input subsidies resulted in a reversal into more extensive farming systems with more deforestation as a result (Holden 1997; 2001; Holden et al. 1999). It may be more efficient to minimize deforestation by not building roads or improving infrastructure near areas that should remain forested and instead develop infrastructure and promote intensive agriculture in high potential areas and stimulate migration to such areas. Moreover, intensive maize production on such acid soils has its own sustainability problems.

Burke et al. (2017) show that soil acidity is a major constraint to intensification in Zambia and this results in especially low response to basal fertilizer applications because most of the phosphorous in the fertilizer is “captured” by the acidic soils and becomes unavailable to the plants. Continuous maize production with fertilizer has also reduced soil organic carbon (SOC) levels and made the soils even more acidic and this also contributes to aluminum toxicity and micronutrient deficiencies on these soils (Singh et al. 1995; Woode 1983). Aluminum toxicity is more severe in the subsoils where SOC levels are lower and this can limit rooting depth, the plants' ability to access nutrients and water, with consequences for plant growth and susceptibility to droughts (Lal and Singh 1998). Liming can be used to increase soil pH but high amounts of lime are needed to have a significant impact and the transportation costs have so far been prohibitive in the African context (Burke et al. 2017). There have been attempts at breeding acidity-tolerant crops but these attempts have so far not been very successful for maize (Pandey et al. 2007). Some fertilizers, particularly N fertilizers, contribute to enhancing soil acidity, especially sulfate of ammonia but also urea, while calcium ammonium nitrate (CAN) has a slight positive effect on pH. This implies that sulfate of ammonia should be avoided on acid soils. An environmental externality perspective on soil acidity may also point in direction of a tax rather than a subsidy on urea while it can be easier to defend a subsidy on CAN. One could also argue for subsidies on lime but more research is needed to assess its cost-effectiveness (Burke et al. 2017; Øygard 1987). It may, however, be possible to ameliorate aluminum toxicity and phosphorus fixation in soil by addition of organic residues (Haynes and Mokolobate 2001). More research is needed to find the best ways to maintain or enhance SOC levels in soils and reduce soil acidity and toxicity problems related to intensive cultivation of acidic tropical soils. Soil carbon sequestration can also be a way to mitigate or reduce the speed of climate change (Lal 2004).

Bhargava et al. (2018) combine the World Bank's Living Standard Measurement Survey (LSMS) data with high-resolution remote-sensing soil data and find a strong positive correlation between SOC content and agricultural profitability and with higher sensitivity for farmers with poorer quality land. The question is how best to raise SOC levels. The following approaches have received considerable attention in recent years as potential solutions.

Conservation Agriculture (CA) with the three principles minimum soil disturbance, soil coverage with organic matter and crop rotation/intercropping, has been proposed and tested as a way forward for sustainable intensification in SSA (Hobbs et al. 2008; Giller et al. 2009, 2015). CA can contribute to raise SOC and has been promoted in several SSA countries (Giller et al. 2015). CA has received a lot of support from donors but has shown disappointing adoption levels so far compared to in Latin-America (Arslan et al. 2015; Giller et al. 2009, 2015; Fisher et al. 2018; Holden et al. 2018).

Vanlauwe et al. (2014) have argued that CA needs to be combined with a fourth principle in SSA, the use of adequate quantities of inorganic fertilizer. This is consistent with the Integrated Soil Fertility Management (ISFM) approach which is defined as a set of soil fertility management practices that combines fertilizer, organic inputs, improved germplasm and knowledge of how to adapt these to local conditions to maximize agronomic use efficiency of the applied nutrients in improving crop productivity, based on sound agronomic principles (Vanlauwe et al. 2010; 2015). Yet the widespread adoption of ISFM is lacking, perhaps partly for the same reasons as for CA and/or the complexity of adapting the principles in highly heterogeneous agro-ecological and socio-economic conditions. Such adaptation is highly knowledge intensive and may be beyond the capacity of smallholder farmers without sophisticated management advice.

Holden et al. (2018) found that low adoption rates of CA in Malawi was caused by low short-term returns and high initial labor or cash costs due to weed control problems. They think that the adoption hurdle may be overcome with an orchestrated transition using herbicides and fertilizers with technical support (especially for weed control) to raise short-term returns while also relieving labor and cash constraints till a more productive and less labor demanding CA/ISFM production system has been established. Such an approach may qualify as a market smart subsidy package but will require pilot testing before scaling up.

Another strand of the literature has studied nutrient flows and land degradation in Africa (Stoorvogel and Smaling 1990; Lal 1998). Large net nutrient losses were observed in many African farming systems and particularly so on the more densely populated and intensively utilized fertile soils. However, research has shown that net loss of nutrients may not result in declining yields in the short run as some soils have high stocks of some nutrients (Vanlauwe and Giller 2006). Net nutrient loss may thus not necessarily represent an environmental externality that merits intervention. However, there are situations where such nutrient leaching are associated with severe erosion and land degradation with declining land productivity as an outcome and where interventions are needed to reduce the extent of leaching, erosion and land going permanently out of production (Shiferaw and Holden 1998; 1999). Evidence showed that smallholder farmers had insufficient incentives on their own to implement conservation investments do to the low short-term returns to such investments and their severe levels of poverty in an environment with highly imperfect factor markets (Holden et al. 2001; Shiferaw and Holden 2000). This could therefore be a case where an input subsidy could be argued for if it could be used to stimulate conservation investments and enhance short-term returns to such investments. This rests on the combined situation of poorly functioning factor markets and poverty associated with myopic behavior limiting investment (Holden et al. 1998). The primary policy tool used was food for conservation work, which has taken place at large scale in Ethiopia, and where access to subsidized fertilizer also has contributed to raising the short-term returns to conservation. It is interesting that fertilizer for conservation work has not been used as an alternative approach in the Ethiopian case while this at one point was attempted in Malawi. The implicit fertilizer subsidy in Ethiopia is of the old universal type and is not targeted by use of vouchers like in some of the other countries (Jayne et al. 2018).

How does fertilizer subsidies affect the adoption of natural resource management (NRM) practices? This is likely to depend on complex substitution and complementarity relationships between inputs as well as outputs. On the one hand, it is possible that cheap fertilizers become a substitute for other but more costly yield-enhancing inputs. On the other hand, it is possible that the use of certain NRM practices also enhances fertilizer use efficiency. Evidence from Malawi indicates that fertilizer subsidies have weak or mixed effects on various NRM practices (Holden and Lunduka 2012; Katengeza et al. in press). A different targeted or conditional subsidy is required if certain NRM practices are to be stimulated in combination with fertilizer use.

4.3. Incentives and behavioral constraints

Potential behavioral constraints were indicated in the previous section such as impatience and risk perceptions that may undermine incentives to invest. There is growing evidence in the behavioral and experimental economics literature that some of the systematic deviations from Expected Utility Theory may be of importance and relevance here. Anomalies in inter-temporal choice associated with high discount rates, present bias, hyperbolic responses and magnitude effects are examples (Holden et al. 1998; Holden and Quiggin 2017a). In the risk domain, risk aversion in small gambles, limited asset integration, probability weighting, and reference-dependent utility are examples (Binswanger and Rosenzweig 1981; Rabin 2013; Tanaka et al. 2010; Holden and Quiggin 2018). Further studies of these behavioral anomalies can be instructive and have policy relevance.

Duflo et al. (2011) found that Kenyan farmers underinvested in fertilizer when it was profitable and associated this with impatience and time-inconsistent behavior. They suggested and demonstrated that, rather than selling fertilizer at subsidized prices at planting time, it may be cheaper and stimulate fertilizer use as much to sell farmers unsubsidized fertilizer at harvest time when farmers just have sold their crops and still have cash. Holden and Lunduka (2014) investigated whether a similar approach could work in Malawi. The main problem with the approach was that output prices are much lower at harvest time than at planting time while fertilizer prices do not vary in the same way. Cash constraints may force households to sell their crops at a low price at harvest time rather than storing them and selling them at a higher price closer to planting time (enabling them to buy even more fertilizer). Selling fertilizer to farmers at harvest time may therefore not solve the cash liquidity problem. It therefore seems that cash and credit constraints are the underlying constraints explaining low fertilizer use while unconstrained demand is very high in Malawi (Holden and Lunduka 2014). Other studies have assessed the profitability of fertilizer use in Kenya and concluded that fertilizer rates are close to optimal and thus fertilizer use is constrained by low profitability (Suri 2011; Sheahan et al. 2013).

Fertilizer is a risky input in risky environments and it is optimal for a risk averse producer to use less of the risky input than a risk neutral producer (Sandmo 1971). Smallholder farmers have been found to be risk averse in the sense that they have concave utility functions (Binswanger 1981; Wik et al. 2004; Yesuf and Bluffstone 2009). More recently rank dependent utility and prospect theory have been used to derive risk attitudes and associated this with not only concavity of the utility function but also subjective probability weighting and loss aversion (Tanaka et al. 2010; Liu 2013; Liu and Huang 2013; Holden and Quiggin 2017b; 2018). Holden and Quiggin (2018) find that overweighting of low probability bad events such as drought is associated with lower intensity of fertilizer use. Such overweighting of low probabilities was dominant in their sample of smallholder farmers in Malawi. Such overweighting is also found in studies in Vietnam, China and Ethiopia (Tanaka et al. 2010; Liu 2013; Vieider et al. 2018). While it is possible that low use of risk complementary inputs such as fertilizer is widespread, this requires further research. A recent study in Tanzania and Uganda, building on expected utility theory, also emphasized that the cost-increasing nature of investment in fertilizer makes it risk-increasing and cause moderately risk-averse farmers to buy less fertilizer, and this may also explain low demand for fertilizer in these countries (Mukasa 2018). This evidence is, however, insufficient to argue for a fertilizer subsidy.

Resource poverty and short-term need constraints may limit conservation investments that only give positive returns after several years, and such constraints may be the main reasons for under-investment in conservation in settings with pervasive factor market imperfections (Binswanger and Rosenzweig 1986; Holden et al. 2001). Such market imperfections are rooted in fundamental resource and behavioral characteristics that modern information technologies cannot fully overcome (Sheahan and Barrett 2017). Institutional innovations will therefore continue to play an important role to enhance investment incentives and promote rural transformation and economic development but fertilizer subsidies may not necessarily be a part of such institutional designs.

5. Institutional Constraints and Opportunities

Input subsidy programs should by now have a sufficiently long history to facilitate learning from past errors, even in the case of the so-called smart subsidy schemes implemented in SSA after 2005. I first outline some of the fundamental design and implementation challenges. I then summarize the evolution in a couple of countries (Sri Lanka and Malawi) and assess whether historical experience has resulted in refined and better designs in these two countries.

5.1. Design and implementation of fertilizer subsidy programs

A review of past and contemporary fertilizer subsidy programs reveals many problems that contribute to low and sometimes unintended impacts and low returns to these programs. We may broadly classify these failures into design failures and implementation failures although these two categories are also interconnected.

Design failures

a) Unclear and complex or contradictory objectives provide insufficient basis for developing smart design. For example, it may not be clear whether the subsidy program should address specific market failures, externalities, producers, consumers, short-term versus longer-term outcomes, or distributional outcomes (Druilhe and Barreiro-Hurlé 2012). Several programs have in particular aimed to enhance food security and recovery after a food crisis (safety net objective).
b) Failure to carefully diagnose the characteristics of the economy and identify the relevant market failures/externalties where a subsidy potentially could enhance efficiency. This includes failure to address multiple constraints by making subsidies an integrated part of a holistic policy (Michael et al. 2018). Such failures may also relate to the heterogeneity of agro-ecological and socio-economic characteristics which may imply that multiple and heterogeneous market failures/externalities exist which cannot be addressed with a “one size fits all” subsidy scheme.
c) Universal designs without exit strategy dominated the first generation of fertilizer subsidy schemes. Universal fertilizer subsidy is costly and benefits mostly those who

use a lot of fertilizer (large farmers growing fertilizer intensive crops). This can lead to overuse of fertilizer in areas where farmers are familiar with fertilizer and have easy access to it. Overuse may not only result in low marginal returns (in-efficiency) but also in pollution of groundwater, rivers and lakes, and soil acidification. Such effects have been observed in India, Sri Lanka and China where fertilizer use levels are already high (Gautam and Kar 2014; Li et al. 2013; Wang et al. 2011; World Bank 2014, cited by Gautam 2015).

d) Targeting design errors can include unclear or contradictory targeting design criteria in the second generation targeted fertilizer subsidy programs (Jayne et al. 2018). Competing stakeholder groups and political influence may result in inconsistent targeting objectives. Such design errors can result in failure to address relevant market failures/externalities, failure to target intended beneficiaries (errors of exclusion and errors of inclusion), and unintended effects with efficiency, equity and sustainability implications (Jayne et al. 2018).

e) Lack of an explicit and clearly specified exit strategy. This may be the result of political pressure and the short-term objectives of political pressure groups and decision-makers (Gautam 2015; Jayne et al. 2018).

f) Lack of a comprehensive monitoring and impact assessment system. It is demanding to have such a system in place and political leaders may prefer systems that give them more freedom to act without the consequences of their actions to be carefully monitored or revealed. Underinvestment in monitoring and impact assessment is therefore widespread and contributes to poor evaluation of input subsidy programs (Ravallion 2009).

Implementation failures

Implementation failures include failures where the objectives and designs are clear but the problems relate to their implementation. Such failures include; a) inefficient and incomplete implementation due to incompetent and unmotivated administrators; b) rent-seeking and leakages causing diversion of funds; c) targeting errors (errors of exclusion and errors of inclusion). These may partly be outcomes of the first two points, unclear objectives and weak monitoring systems; d) late delivery of inputs; and e) crowding out of private sector agents.

While these implementation failures are widespread and known, they appear pervasive.

5.3. Evolution in the designs: Do we see an improvement?

We assess this by looking at a two countries, one in Asia (Sri Lanka) and one in Africa (Malawi), where fertilizer subsidies have played a prominent role.

Sri Lanka

Sri Lanka was one of the early adopters of fertilizer subsidies, which were introduced in 1962 with the objective to encourage farmers to switch from traditional rice varieties to high-yielding and fertilizer responsive varieties. Since then fertilizer subsidies have been part of the agricultural policies except for the short period 1990-94 (Weerahewa et al. 2010). The sign of the fertilizer subsidy has varied over time from a general subsidy of all fertilizers in the periods 1962-89, 1995-96, 2006-09. The subsidy levels for different types of fertilizer have also varied over time from being uniform across all fertilizers to applying only for some fertilizers in other periods. Fixed fertilizer prices to farmers have been implemented in periods regardless of world market prices. The subsidy rates have varied over time from a uniform rate of 33% in 1975, to 50% in 1978, and a differentiated rate of 85% for urea and 75% for other fertilizers in 1979, complete removal of subsidies on sulphate of ammonia and rock phosphate in 1988, complete removal for all types of fertilizer in 1990-94, and frequent variations in the following years. Fixed fertilizer prices and variable subsidy levels were introduced in 2006 and resulted in sharp increases in subsidy rates and expenditures in the following years with the increases in international oil, fertilizer and food prices. The political pressure is strong for continuing the fertilizer subsidy scheme in Sri Lanka because the subsidies are perceived to benefit large shares of the rural population including 1.8 million smallholder paddy farmers. Continuing or improving the subsidy program are popular promises during elections by ruling and opposition parties and is closely associated with food security (protection against price fluctuations) and poverty alleviation in the country rather than the alleviation of specific market failures or externalities. It therefore serves, and is perceived, as more like a social welfare program than a program that enhances efficiency (see Weerahewa et al. (2010) for more details).

Malawi

Malawi, like many other countries in Africa, introduced general fertilizer subsidies as part of the agricultural policies in the 1960s and 70s where input and output prices were regulated (pan-territorial pricing) and implied a substantial taxation of the agricultural sector even though fertilizer and other input subsidies were present (Krueger 1991). National food security was a high priority in Malawi and was strongly maize focused through smallholder production while the estates focused on cash crop production for export. With increasing debt problems there was a change in policies in the 1980s based on guidance and pressure from the World Bank and IMF to implement stabilization and structural adjustment reforms. These reforms included removal of price controls and input subsidies. Larger fluctuations in maize production were experienced in the following years with large deficits in some years such as 1987, 1992, and 1994, following droughts. This was also a turbulent period for agricultural policies in the country including a collapse in the agricultural credit program due to a combination of unrealistic political promises, droughts and production failures. A Drought Recovery Input Programme was introduced in 1993 and distributed free seeds and fertilizer to 1.3 million smallholders (Devereux 1997). It was followed up by a Supplementary Inputs Project targeting 0.8 million households in the following year with seeds and fertilizers and a Poverty Alleviation Program providing public works with self-targeted food and cash for work (ibid.). Following the next severe food deficit in 1997 the Starter Pack program was introduces and distributed free maize seeds (2 kg high-yielding hybrid), fertilizer (15 kg) and legume seeds (1 kg) to 2.8 million households. After two years, the program was replaced by the Targeted Input Program (TIP) and scaled down to reach 1.5 and 1.0 million households in 2000 and 2001 to reduce the financial burden (Harrigan 2008). The program was again scaled up with the Extended TIP in 2002-2003 to reach 2.8 and 1.7 million households.

Following a new and severe production failure due to drought in 2004/05, making 5 million people dependent on food aid, a new scaled-up input subsidy program that received considerable international attention, was introduced from 2005/06 (Denning et al. 2008). The new program distributed input packages about four times the size of the Starter Packs (0.4 ha vs. 0.1 ha) with seeds and fertilizer at highly subsidized prices through a voucher system. Malawi’s President Bingu wa Mutharika argued that it was cheaper to import fertilizer than maize. With the input subsidy program, maize yields and production doubled compared to the previous drought year. The subsidy program continued the following two years with good rainfall and some surplus maize was exported in a period when international cereal prices increased sharply together with oil and fertilizer prices. These price increases contributed to the financial burden of the input subsidy program, which had to be scaled back despite its national popularity. The international and national success contributed to the re-election of President Mutharika in 2009 but his popularity crumbled after that with the growing number of problems that followed such as high food prices, fuel shortages, cutback of the subsidy program and budget deficits. Targeting of the scaled-down program, who to target, and how to achieve the targeting objectives became central issues. A number of impact studies revealed partial crowding out of commercial demand, late delivery of inputs, inefficient targeting and diversion of inputs, leading to lower production and welfare effects than earlier anticipated (Dorward and Chirwa 2011; Chirwa and Dorward 2013; Holden and Lunduka 2010; 2013; Ricker-Gilbert et al. 2011; 2013a; 2013b; Lunduka et al. 2013; Jayne and Rashid 2013). While weaknesses were revealed and attempted remedied, the efforts to reduce targeting errors and diversion problems appear not to have been very successful (own household panel data for the period 2006-2015; AGRA 2017). Recently, more subsidies have gone to more productive farmers while the poorer and more vulnerable should be helped by the safety net program. This could enhance fertilizer use efficiency but also enhance crowding out. A positive outcome has been documented recently is that the subsidy program has contributed to speeding up the dissemination and adoption of drought-tolerant maize varieties (Holden and Fisher 2015; Holden and Quiggin 2017b; Katengeza et al. 2018).

6. Impacts and Economic Returns

6.1. Impact Studies

I benefit from the selection of high quality impact studies in the systematic review by Hemming et al. (2018) and the stock-taking of the second generation input subsidy programs by Jayne et al. (2018). This review attempts not to repeat but to add to these recent reviews by briefly summarizing and drawing on their central findings. Table 1 summarized key impacts in terms of intended effects based on studies reviewed by Hemming et al. (2018). Table 2 summarizes findings of unintended effects based on studies reviewed by Jayne et al. (2018). An overview of findings on overall economic returns to fertilizer subsidies in Asia and SSA finalizes this part, before I conclude.

Table 1. Overview of impact studies for 'smart' (targeted) subsidy programs: Intended impacts

Impact & Source	Countries	Key Finding
Fertilizer adoption Hemming et al. (2018)	Malawi, Zambia, Mali, Mozambique	Based on six studies fertilizer adoption rates are on average 23% higher among subsidy recipients than non-recipients
Crop yield Hemming et al. (2018)	India, Malawi, Mozambique, Nigeria, Tanzania	Crop yields are on average 11% higher for recipients than for non-recipients, higher for maize (18%) and rice (25%).
Income Hemming et al. (2018)	Malawi, Nigeria, Zambia	Average income increased by 15% for recipients as compared to non-recipients of input subsidies, based on three studies

Sources for Hemming et al. (2018): Awotide et al. (2013), Bardhan and Mokerjee (2011), Carter et al. (2013), Chibwana et al. (2010), Chirwa (2010), Holden 2013, Karamba (2013), Mason and Smale (2013), Mather and Kelly (2012), World Bank (2014a).

Table 2. Overview of impact studies for 'smart' (targeted) subsidy programs: Unintended impacts

Crowding out/in of commercial demand for fertilizer	Country	Finding
Ricker-Gilbert et al. (2011)	Malawi	Crowding out 0.22kg/kg subsidized fertilizer. Less for poor households (18%) than for rich (30%)
Xu et al. (2009)	Zambia	Crowding out 0.07-0.08 kg/kg subsidized fertilizer
Mason and Jayne (2013)	Zambia	Crowding out 0.13kg/kg subsidized fertilizer, Higher where commercial sector is developed (0.23) than where it is not (0.07), higher for farms>2ha (0.21) than for farms<2ha (0.11), higher for male-headed households (0.15) than for female-headed households (0.09).
Liverpool-Tasie (2014)	Nigeria	Find evidence of crowding in commercial demand for fertilizer in Kano area where the private sector is weak
Takeshima and Nkonya (2014)	Nigeria	Access to 100 kg subsidized fertilizer reduces the probability of participation in the commercial fertilizer market by 10-21%
Targeting errors		
Holden and Lunduka (2012)	Malawi	Target group (resource-poor farmers) less likely to receive subsidized inputs than in a program with random distribution of inputs
Kilic et al. (2014)	Malawi	The program does not in reality target the poor.
Pan and Christiaensen (2012)	Tanzania	Decentralization of targeting to local authorities does not improve targeting. Local elites capture most of the benefits.
Banful and Olayide (2010)	Nigeria	Widespread evidence that subsidized fertilizer is often captured by wealthy elites.
Diversion/Leakages		
Holden and Lunduka (2010, 2012)	Malawi	30-35% of input subsidies have diverted (leaked out) before reaching target communities, diversion of vouchers as well as fertilizer.
Dorward and Chirwa (2011)	Malawi	Voucher allocation to "ghost" beneficiaries, printing and distribution of fake vouchers.
Mason and Jayne (2013)	Zambia	33% of the fertilizer under the subsidy program does not reach the farmers through the program.
Banful and Olayide (2010)	Nigeria	Fertilizer is regularly stolen from the state government fertilizer depots. Subsidized fertilizer is used to reward officials for providing political support. Officials have been found conspiring with smugglers to transport fertilizer subsidized by the Nigerian government into neighboring countries. Officials in charge of monitoring the distribution of subsidized fertilizer have also been caught in scandals to divert fertilizer to their private warehouses and retail outlets.
Liverpool-Tasie and Takashima (2013)	Nigeria	More than 50% of the fertilizer distributed through the subsidy program has been diverted.
Jayne et al. (2015)	Kenya, Malawi, Zambia	36% (Malawi), 23% (Zambia) and 19% (Kenya) of the subsidy transfer is appropriated by diverters over a five year period.
Late delivery of vouchers and inputs		
Druilhe and Barreiro-Hurlé (2012)	Ghana, Mali, Malawi, Senegal	Late delivery of vouchers
Banful (2009)	Ghana	Only half of the distributed vouchers delivered were redeemed due to late delivery
Banful and Olayide (2010)	Nigeria	Late delivery and no delivery of fertilizer to local depots due to inefficient distribution through formal channels and leakages.

6.2. Return to Investment Studies

Ideally, benefit-cost ratios (BCRs) for programs should be judged against the best alternative uses of the same funds. In most countries it is difficult and demanding to find such data. Few such assessments have therefore been made in the case of fertilizer subsidy programs. Fan et al. (2008) is an exception.

Fan et al. (2008) have estimated the marginal returns to alternative investments in rural areas in India over the period 1960-2000. The types of investments compared were roads, education, irrigation investments, irrigation subsidies, fertilizer subsidies, power subsidies, credit subsidies and agricultural research and development (R&D). They found high returns to all these during the 1960s-70s during the Green Revolution, with roads, education, credit subsidies and power subsidies giving the highest returns and fertilizer subsidies and irrigation subsidies giving the lowest, but still high, returns. The returns declined in the 1980s for all categories except fertilizer subsidies, which still had the lowest return (BCR=1.94). In the 1990s fertilizer subsidies gave negative returns (BCR=0.85), while all other categories gave positive returns. Roads, agricultural R&D and education continued to give the highest returns (BCRs: 5.46-9.5). All subsidies in India amounted to about 2% of national GDP and 8-10% of agricultural GDP. Fan et al. (2008) conclude that the subsidies are in direct competition with more long-term investments in roads, education and agricultural research and therefore undermine long-term growth and poverty reduction.

For African countries, Jayne et al. (2013) estimated benefit-cost ratios (BCR) for the input subsidy programs in Kenya, Malawi and Zambia. These estimates were questioned by Dorward and Chirwa (2015), who provided alternative higher estimates, and Jayne et al. (2015) provided corrected rates based on the comments but these rates were still lower than those of Dorward and Chirwa. The corrected BCRs for a five year period (2006-2010) are 1.72 (Kenya), 1.26 (Malawi) and 0.86 (Zambia), including the diverted benefits to the rent-seekers. Dorward and Chirwa (2015) assume higher returns to fertilizer use while studies of such returns indicate that Jayne et al. (2015) have used more appropriate maize-fertilizer return estimates. Jayne et al. (2018) provide a more comprehensive review of maize-fertilizer returns in a number of countries. The BCRs are also sensitive to maize and fertilizer prices and do not take into account the specific situations after a drought shock which in some countries triggered the scaling up of the subsidy program. The rates do not include multiplier or general-equilibrium effects, which would push in direction of higher overall returns and there are no comparisons with alternative investment options such as infrastructure investments, agricultural extension service or R&D. We see, however, that there are large differences in the estimated BCRs and with Zambia's program being the most questionable demonstrating negative returns.

7. Conclusions

This review has revealed that the second generation socalled market smart targeted input subsidy programs that have been implemented primarily in SSA since 2005 far from live up to the theoretical ideas they were built on. Most of the programs violate many of the basic principles that were outlined by Morris et al. (2007). The review has revealed that most of these programs suffer from substantial design and implementation errors. This may give reason to question whether the design principles were unrealistic as guidelines or whether the identified weaknesses should be easy to fix. The failure to design and implement an exit strategy is the obvious example as poorly designed and implemented programs are continuing. The fundamental reason for this is that they have been captured by elites who are able to reap the lion's share of the benefits and at the same time gain political support from the rural masses that hope to benefit from the subsidies. While corrupt practices have been revealed and shown to be massive, public knowledge of the problem has to limited extent resulted in improvements. While European countries, such as Norway, have implemented well-targeted subsidy programs, these typically rely on reliable coupled land and farmer registries, which only partially exist in SSA countries. The administrative costs therefore remain very high. However, the costs of land registration and certification have been fallen dramatically and some SSA countries are investing in establishing such registries that in the future also potentially may be used for spatially targeted investments to enhance sustainable land use where subsidies could be part of an incentive package. This could facilitate transparency as well as minimize the administrative costs by utilizing electronic transfers where satellite imagery could help to verify the implementation of specific visible investments in target areas. Rwanda is the SSA country, which is closest to being able to implement such an approach, with Ethiopia as the second candidate as it is also progressing in establishing modern low-cost land registries in areas with high agricultural potential.

There are few signs that the Malawian FISP, which is the SSA program that has received most attention, has moved towards a smarter design. While the program has contributed to speeding up the adoption of drought tolerant maize after recent droughts, there are still fundamental problems with crowding out, targeting, diversion, late delivery and consequent inefficiencies. The high financial costs has forced a scaling-down of the program but politicians see the program as an important tool that can help them to win the next election. The subsidy program is therefore more sticky than smart. This seems to be more due to a power trap (elite capture) than a poverty trap because the lion's share of the benefits from the subsidy program benefit the diverters. While a pilot experiment was included in the program last year to target more productive farmers, hoping that this can increase the returns to the program, this is also likely associated with more crowding out as more productive farmers are more likely to be able to purchase fertilizer at commercial price. This shows that 12 years after the FISP was first implemented, the implementers have not found a smart targeting approach that does not lead to inefficiencies.

The subsidy programs are locally among the broader public perceived as social welfare programs rather than efficiency-enhancing policy instruments. This creates a gap between their view and the view of economists who aim to design policies to eliminate market failures. This also creates a barrier towards moving towards more market smart designs. Smart designs also require even smarter and more professional designers and implementers that are motivated to achieve the official goals of well-designed market smart programs. The social welfare focus of many of the programs point in direction of safety net programs as an alternative to achieve this. Or, a combination or integration of the two approaches may facilitate the simultaneous achievement of targeting of vulnerable groups and productive investments with more long-term productivity and sustainability impacts. This requires a targeted and conditional use of subsidies associated with offers of Food-for-work and/or Fertilizer-for-work where the work represents productive investments in local public goods such as soil conservation, irrigation, or tree planting. It is thereby possible that a fertilizer subsidy linked to a conservation requirement not only can enhance fertilizer use but can also enhance conservation and thereby fertilizer use efficiency (Holden and Binswanger 1998). This has been demonstrated with bio-economic models in the context of smallholder agriculture in the Ethiopian highlands (Holden, Shiferaw and Pender 2005; Holden, Barrett and Hagos 2006). Some of these ideas have been implemented under the Productive Safety Net Program (PSNP) and related programs in Ethiopia. The approach is better suited to address land degradation problems that also are associated with low profitability of fertilizer use. Such a conditional and conservation-oriented approach may not only be market smart but also conservation smart. A built-in flexibility in the program such that payment for investment in conservation or other public goods could be for one or more of either productive inputs such as fertilizer and improved seeds, food to meet immediate needs, or cash, depending on local needs. Spatial/geographic targeting should play a stronger role and technically skilled people rather than policy-makers and local leaders should lead the technical implementation while ensuring strong local participation in the identification of priorities. The program could respond to shocks and be scaled up in more severely affected areas after shocks such as droughts and thereby also be climate smart. Such a program would require skilled and motivated implementers that have the power and motivation to prevent and eliminate elite capture. Pilot-testing before scaling up such programs could enhance efficiency and reduce risks of large-scale implementation errors.

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