

**CAN INPUT SUBSIDY PROGRAMS CONTRIBUTE TO CLIMATE
SMART AGRICULTURE?**

By

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EXECUTIVE SUMMARY

Climate smart agriculture (CSA) has emerged as an approach to enhance the resilience of farm systems to the effects of climate change. CSA is defined by three principle objectives: 1) sustainably raising agricultural productivity and incomes; 2) adapting and building resilience to climate change, and; 3) reducing and/or removing greenhouse gases emissions, where possible (FAO 2013). In Africa, there is particular interest in identifying strategies to achieve the first two objectives. This, in turn, requires that farmers adopt practices and technologies that enable their farms to be more resilient, sustainable and productive, while at the same time identifying system-wide collective action to promote a wide range of *ex ante* climate risk management activities and *ex post* coping strategies. Given the scope and scale of these requirements, leveraging public sector resources is critical.

Input subsidy programs (ISPs) provide a potentially useful means to encourage system-wide and farmer-level changes to achieve CSA objectives. The objective of this study is to examine the scope for ISPs to contribute to CSA objectives in Africa. To assess this potential, we adopt the 2x2 matrix framework of Lipper et al. (2014). On one dimension is the temporal element of ISPs, e.g., their *ex ante* climate risk management potential and *ex post* recovery and coping potential. The other dimension distinguishes between responses at the household/farm level vs. responses at the system-wide/government level.

While recognizing that there is limited consensus within the agricultural and soil science disciplines regarding the suite of technologies and practices that are best suited to improve and stabilize smallholder yields in the context of increasing climate variability, the literature on CSA most frequently cite the following practices as potentially climate smart under certain conditions: minimum soil disturbance (zero or minimum tillage); crop rotation and intercropping, particularly with legumes; mulching; crop residue retention; cover cropping; agro-forestry; water management, including irrigation and drainage; integrated soil nutrient management, including efficient use of mineral fertilizer in combination with organic sources; and the use of high quality, well-adapted seed varieties. We assess the current and potential relationships between ISPs and some of these practices and technologies.

Using the 2x2 conceptual lens described above, the report highlights the following key findings.

***Ex-ante* Risk Management at Household Level**

Empirical evidence on the relationship between ISPs and household practices that may contribute to *ex ante* risk management in the context of climate change is thin, but suggests that in most cases ISPs have had either no effect on or have reduced SSA smallholders' use of potentially CSA practices. For example:

- In Ghana ISPs did not affect farmers' investment in soil and water conservation, broadly defined (Vondolia, Eggert, and Stage 2012);
- In Zambia, ISPs have negatively affected crop rotation and fallowing. The program has contributed to continuous cultivation of mono-cropped maize over time and within seasons in Zambia, all of which degrades soils, contributes to maize disease and pests, and leaves smallholders more vulnerable to climate shocks—the antithesis of CSA (Holden and Lunduka 2010, 2012; Levine 2015);
- ISPs are shown to have no or a negative effect on crop diversification (Chibwana, Fisher, and Shively 2012; Mason, Jayne, and Mofya-Mukuka et al. 2013); and

- ISPs are frequently plagued by late delivery, which contributes to reduced yield benefits from inputs (Xu et al. 2009; Lunduka, Ricker-Gilbert, and Fisher et al. 2013; Mason, Jayne, and Mofya-Mukuka et al. 2013; Namonje-Kapembwa, Jayne, and Black et al. 2015).

However, recent innovations in ISPs may address some of the constraints to being more climate smart. In particular, moves toward open voucher systems that crowd in, rather than crowd out, the private sector hold potential to support the development of profitable and potentially more sustainable input distribution systems aimed at smallholder farmers. Moreover, moving from traditional systems that prescribe a set input packet, regardless of prevailing agro-ecology, to a system that provides farmers with a wide range of input choices, including livestock inputs, has the potential to promote greater livelihood diversification, and potentially greater livelihoods resilience. These outcomes, however, are largely conjectural, because there is limited evidence to draw upon to suggest that ISPs as implemented to date have achieved any such benefits.

Additionally, ISPs could be structured in ways that incentivize the adoption of farm management practices that may support more productive and sustainable farming systems. This could occur in a number of ways, including by making farmer participation in ISPs conditional on the adoption of certain practices. This however, would require that ISP implementers are capable of effectively monitoring compliance and that farm management practices can be identified that have clear productivity benefits for targeted farmers. These two requirements currently limit the potential for this strategy to achieve widespread beneficial results.

Finally, ISPs can be used to target specific farmers in specific regions with improved inputs and technologies that can help them be more productive under current and future climate conditions. The most obvious way in which this can occur is through the distribution of drought-, saline-, or heat-tolerant seed varieties. This, however, would likely have to be implemented through a closed voucher system, thus working against current trends toward more open flexible voucher systems. Moreover, these benefits depend on both effective targeting of farmers and regions, as well as the existence of appropriate inputs types and extension advice to use them effectively.

Ex-ante Risk Management at a System-wide Level

Due to their scale, ISPs may have greater capacity to influence the broader systems within which farmers operate and thereby influence farmer behavior both directly as well as indirectly through system-wide changes. We identify three potential areas where these system-wide effects are most evident:

1. First, by expanding and stabilizing the demand for specified input types and quantities, ISPs can mitigate some of the persistent risks associated with the commercial production of certain seed types. This includes open pollinating varieties, which may have limited appeal by commercial seed distribution firms, and most legume seeds, which are notoriously hard to forecast demand for. Supporting demand for these seed types through ISPs can help seed supply firms to better plan investments in multiplication and smallholder distribution, thereby helping to address systemic constraints to achieving crop diversification, organic nitrogen fixation, and rotations. However, this potential benefit is diminished by the trend, among donors and governments, to move toward open voucher systems. Thus, in many ways there are important trade-offs to consider when promoting particular ISP distribution modalities. While open vouchers are desirable from a farmer choice perspective, restricted-choice vouchers for particular inputs, such as legume seeds, may be necessary to support system-wide improvements in legume seed supply chains. Restricted-choice vouchers may be justified in some instances where there are major beneficial externalities associated with promoting certain inputs. Similar system-wide benefits may accrue by using ISPs to create

farmer demand for specific drought-tolerant seed varieties or soil amendments such as lime or inoculants, which are currently not widely used by farmers. As with legume seeds, promoting the utilization of these inputs may require using restricted rather than open voucher systems.

2. Second, ISPs may promote system-wide CSA resilience through promoting *market smart* private investments. The tendency to move toward more market-friendly ISPs may help to promote greater private investments in input supply chains, and in some cases private extension services, which will help to further the CSA objective of sustainably improving and stabilizing yields. By encouraging the development of commercial input supply chains, market-friendly ISPs can foster improved input access conditions for farmers and thus allow them to be less dependent on public input supply systems. Private input systems may be less prone than public systems to delivery challenges associated with logistical and financial constraints. However, there is concern about the capacity of market smart ISPs to effectively serve outlying and low agricultural potential regions. Nonetheless, there seems to be clear potential for ISPs to promote system-wide investments that are both climate smart and market smart and synergistic in their promotion of community resilience to climate variability.
3. Third, the move toward digital platforms for delivering ISPs, such as e-vouchers, creates opportunities to use ISPs as delivery mechanisms for other sorts of products, such as weather indexed insurance. This requires that ISP farmer registries collect a wide range of information on beneficiaries, including geographic location and bank information. With this sort of information, ISPs can defray the screening costs of identifying farmers and managing insurance payouts when necessary.

However, because ISPs can involve significant use of scarce public resources, the opportunity cost of ISPs must be considered. Using ISPs to contribute to CSA objectives would need to be evaluated against the potential benefits of using comparable resources for investments in irrigation, physical infrastructure, and public agricultural research and extension programs, which may generate higher comprehensive social benefits (e.g., Fan, Gulati, and Thorat 2008; Economist Intelligence Unit 2008).

Ex Post Coping at a Household Level

Governments frequently use ISPs to support food system and farm-level recovery from adverse climate and food price events. For example, ISPs can be scaled-up in the year following a severe weather event as part of recovery strategies. In such cases, ISPs can promote smallholder households' ability to acquire improved inputs and re-engage in production following a severe contraction in farm income, and to potentially re-stock depleted resources that were expended during the crisis to smoothen consumption. ISPs can also be used to support replanting efforts in cases of poor germination or early season crop losses due to late or false onset rains or pest outbreak. These are potentially important household-level coping benefits. However, to effectively achieve *ex post* coping benefits for smallholder households, ISPs require significant budgetary flexibility, in order to respond quickly to weather events, as well as managerial flexibility and capacity.

Ex Post Coping at a System-Wide Level

In their current form, ISPs tend to be costly, and therefore compete directly for scarce public sector resources with other CSA risk coping and response strategies that might have more timely and direct impacts, such as disaster risk management plans at various government scales, rapid repair of damaged infrastructure, emergency feeding, etc. However, modifications that enable ISP beneficiaries to gain access to weather insurance could help farmers to avoid the sort of asset and resource depletion that is common after a weather shock to smallholder systems. This, of course, is contingent on the

effectiveness of these insurance programmes to deliver adequate and timely payments to affected farmers. In these ways, ISPs do offer some potential avenues for support food systems and economies to recover following an adverse weather shock, though the ability to realize these benefits will depend on performance in other aspects of the overall system.

Recommendations

ISPs may serve several catalytic functions at a system-level, including seed systems and input distribution system, which can support CSA objectives. However, substantially improving the performance of ISPs will require coordinated public and private investments in areas such as site-specific adaptive research and extension, which are necessary to turn potential CSA practices into profitable and adoptable farm management strategies.

Based on this analysis we propose the following as potential focal areas for improving the climate *smartness* of ISPs in Africa:

- Support greater concentration of ISPs on climate smart seed varieties, including drought and heat tolerant varieties and legumes. Many ISPs currently focus primarily on staple cereal crops and fertilizers, with little attention paid to the characteristics of either. For ISPs to have a more system-wide effect on cropping systems and management practices, seed system constraints for other crops must be addressed. ISPs can serve a catalytic role in this respect.
- Develop detailed farm registries for ISP beneficiaries: Detailed registries, that include geo-spatial information, are necessary to delivery support services such as weather-indexed insurance to farmers and to track adherence to targeting criteria.
- Explore the potential for using ISPs to overcome CSA farm management adoption constraints, bearing in mind that:
 - There is currently limited consensus on what practices are most effective for heterogeneous smallholder systems;
 - Extension advice and monitoring capacity remains very thin in most of Africa; and
 - Governments may resist changing ISPs in ways that as yet have unproven benefits or may not be popular with farmers.
- System support to improve timing of input distribution through ISPs: ISPs chronically deliver fertilizer late (Xu et al. 2009; Namonje, Jayne, and Black 2014; Snapp and Fisher 2015). Late delivery reduces yields and crop response to fertilizer. This unfavorably affects the ratio of crop output to GHG emissions. Improving the timeliness of ISPs would clearly contribute to the achievement of CSA objectives.
- Improve beneficiary targeting of ISPs: ISPs must more effectively target farmers who can use fertilizer profitably but are not already using it (or using it well below levels considered to be profit maximizing). This will reduce crowding out of commercial demand and contribute to increased fertilizer use. In addition, effective targeting of farmers and regions affected by weather-induced disaster can help ISPs to support *ex post* household and system-wide recovery efforts.
- Use extension systems to show farmers how the use of fertilizer from ISPs and/or commercially obtained fertilizer can become more profitable when complementary SI/CSA practices are adopted.

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ACRONYMS

ADMARC	Agricultural Development Marketing Corporation (ADMARC) and
AFRE	Department of Agricultural, Food, and Resource Economics (AFRE) at
CSA	Climate smart agriculture
CT	conventional tillage
DFID	Department for International Development
EIU	Economist Intelligence Unit
EPAs	Extension Planning Areas
FAOUN	Food and Agricultural Organisation
FSG	Food Security Group
FSP	Feed the Future Innovation Lab for Food Security Policy
FTLR	Zimbabwe's Fast Track Land Reform
GHG	greenhouse gas
GMB	Grain Marketing Board
GoZ	Government of Zimbabwe
ha	hectare
hhs	households
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
ISPs	Input subsidy programs
kg	kilogram
MFISP	Farm Input Subsidy Programme (also known as the Agricultural Inputs Subsidy Programme)
MK	Malawi Kwacha
MoAFS	Ministry of Agriculture and Food Security
MRP	Minjingu Rock Phosphate
MSU	Michigan State University
mt	metric ton
MT	minimum tillage
NAIVS	National Agricultural Inputs Voucher Scheme
NGOs	Non-Government Organizations
N	nitrogen
NPK	nitrogen/phosphorus/potassium
NPV	net present value
OPV	open pollinating variety
PAM	Programme Against Malnutrition
PAPA	Plano de Acção para a Produção de Alimentos
R&D	Research and Development
SFFRFM	Smallholder Farmers Fertiliser Revolving Fund of Malawi
SFM	soil fertility management
SI	sustainable intensification
SOAS	School by Oriental and African Studies
SOC	soil organic carbon
SSA	Sub-Saharan Africa
TIP	Targeted Inputs Programme
US\$	United States Dollar

USAID	United States Agency for International Development
VVC	Village Voucher Committee
ZFISP	Farmer Input Support Programme (originally called the Fertiliser Support Programme)
ZMAL	Zambia Ministry of Agriculture and Livestock
ZMFNP	Zambia Ministry of Finance and National Planning
ZMW	Zambian Kwacha

1. INTRODUCTION

There is growing global recognition of the urgent need to identify and implement strategies that make food systems more resilient in the face of increasing climate variability. Nowhere is this more evident than in Sub-Saharan Africa.¹ Because the majority of African's livelihoods and the regional food system rely on rain-fed agricultural systems, Africa is one of the most vulnerable world regions to climate change. The Intergovernmental Panel on Climate Change concluded that "climate change is expected to have widespread impacts on African society and Africans' interaction with the natural environment" (IPCC 2014).

Climate smart agriculture (CSA) has emerged as an approach to enhance the resilience of farm systems to the effects of climate change. As will be discussed in more detail in Section 2, CSA is defined by three principle objectives: 1) sustainably increasing agricultural productivity and incomes; 2) adapting and building resilience to climate change, and; 3) reducing and/or removing greenhouse gases emissions, where possible (FAO 2013). In Africa, and other predominantly agrarian regions, there is particular interest in identifying strategies to encourage farmers to adopt practices and technologies that enable their farms to be more resilient, sustainable and productive, while at the same time identifying system-wide collective action to promote a wide range of *ex ante* risk management activities and *ex post* coping strategies. Given the scope and scale of these requirements, leveraging public sector resources is critical.

Input subsidy programs (ISPs) provide a potentially useful means to encourage system-wide coordination and farmer behaviors that achieve the objectives of improving resilience to climate variability and raising agricultural productivity in Africa, while potentially mitigating the agricultural sector's contribution to GHG emissions. ISPs vary in their distribution modalities and targeting requirements, but generally share the common attributes of providing inorganic fertilizer, and in some countries, improved seed, to farmers at below-market prices. Many African governments currently devote a large share of their agricultural sector and national budgets to input subsidy programs (ISPs). The region spends just over US\$1.0 billion each year on ISPs (Jayne and Rashid 2013; Jayne et al. 2017). A major challenge to enabling ISPs to promote CSA outcomes stems from the major opportunity costs they entail in terms of foregone public spending on other core CSA investments such as irrigation, agricultural R&D, and extension services that could potentially promote CSA practices more effectively per dollar invested than ISPs. However, there is clearly scope for market smart ISPs to promote the development of input delivery systems that would improve smallholder farmers' access to technologies that could improve the stability of yields and overall resilience of African farming systems especially in semi-arid areas.

This paper assesses the feasibility of leveraging public investments in ISPs to promote adoption of CSA practices and technologies by African farmers. The paper is organized as follows. Section 2 begins by defining CSA in the context of African smallholder farming systems. Section 3 describes implementation modalities, the composition of input packs, and expenditures in Zambia, Zimbabwe, Malawi, Tanzania, and Mozambique.

Based on this background, Section 4 systematically examines the range of impact pathways by which ISPs may affect the resilience of African farming systems and their ability to cope with climate-related shocks. ISPs could contribute to CSA and resilience through a variety of pathways and at different levels. We adopt the 2x2 matrix framework of Lipper et al. (2014) to consider, on one dimension, how ISPs may promote resilience of farming systems in the face of climate shocks (*ex ante* risk management

¹ Hereafter *Africa* for short.

strategies), and how ISPs might be designed to support recovery following a climate shock (*ex post* coping strategies). The other dimension distinguishes between potential responses at the household/farm level vs. responses at the system-wide/government level (Figure 1). ISPs, for example, may affect farmers’ willingness to adopt management practices that promote yield stability or other forms of resilience in the face of extreme weather events. This potential for ISPs to contribute to *ex ante* risk management strategies by farmers is considered in Section 4. ISPs may also be designed in ways that encourage input delivery systems for drought-tolerant seeds or other system-wide changes that promote resilience (Section 5). Section 6 examines the ability of ISPs to support household-level recovery from climate shocks once they have occurred. In addition, Section 7 examines the potential of ISPs to promote system-wide changes that support *ex post* coping responses to shocks. Section 8 summarizes our findings and discusses potential implications for ISP policies and programs.

Figure 1. Various Dimensions of How Input Subsidy Programs Might Contribute to Climate Smart Agriculture

		Impact pathway	
		Household-level	System-wide level
Type of strategy	<i>Ex ante</i> risk management: promoting resilience and reducing vulnerability	Section 4	Section 5
	<i>Ex post</i> coping strategies: relieving impacts of climate shocks after they have occurred	Section 6	Section 7

Source: Authors.

2. DEFINING CLIMATE SMART AGRICULTURE

Although not clearly defined in the academic literature, the term *climate smart agriculture* (CSA) has gained prominence as an emergent agricultural development paradigm (Engel and Muller 2016). The UN Food and Agricultural Organisation (FAO) defines it as “an approach to developing the technical, policy, and investment conditions to achieve sustainable agricultural development for food security under climate change” (FAO 2013). It is an approach composed of three pillars: (i) sustainably increasing agricultural productivity and incomes; (ii) adapting and building resilience to climate change, and; (iii) reducing and/or removing greenhouse gases emissions, where possible (ibid). CSA is therefore largely defined by its intended outcomes rather than by a set of practices or approaches (Kaczan, Arslan, and Lipper 2013).

CSA shares many objectives and guiding principles with green economy and sustainable development approaches, including a prioritization of food security and a desire to preserve natural resources (FAO 2013). It is also closely linked to the concept of sustainable intensification (SI) (FAO 2011; Campbell et al. 2014). As the FAO Sourcebook on CSA (2013) states, CSA extends these concepts through “a more forward looking dimension, more concern about future potential changes and the need to be prepared for them” (30). Thus, CSA is not a set of new agricultural practices or a new agricultural system. Instead, it is understood as a new approach to guide necessary changes to agricultural systems in order to jointly address challenges of food security and climate change (Lipper et al. 2014; Branca et al. 2011; FAO 2013; Grainger-Jones 2011).

Proponents of CSA emphasize several hallmarks of a CSA approach. First, CSA focuses intently on weather- and climate-induced risks throughout the food system, with a particular emphasis placed on *ex ante* risks to smallholders resulting from the interaction of current and future climate patterns with existing livelihood vulnerabilities (McCarthy, Lipper, and Branca 2011; Meinzen-Dick, Bernier, and Haglund 2013; Grainger-Jones 2011; World Bank 2011). Second, elevating the visibility of emergent risks smallholders face offers opportunities to focus strategically on practices and technologies that offer multiple benefits in the areas of climate change adaptation, mitigation, and food security. Finally, by linking climate change adaptation and mitigation to smallholder production practices, CSA creates opportunities to link smallholders to previously unavailable sources of support, including climate finance (Meinzen-Dick, Bernier, and Haglund 2013; Grainger-Jones 2011).

Of the numerous farm-level practices associated with CSA in the literature, the most frequently cited include: minimum soil disturbance (zero or minimum tillage); crop rotation and intercropping, particularly with legumes; mulching; crop residue retention; cover cropping; agro-forestry; water management, including irrigation and drainage; integrated soil nutrient management, including efficient use of mineral fertilizer in combination with organic sources; and use of high quality, well-adapted seed varieties. In many cases, these are not new practices, but in the context of African rates of adoption for many of these practices are low or sub-optimal (Branca et al. 2011).

3. ISP PROGRAMS IN CSAP TARGET COUNTRIES

This section reviews ISPs currently or recently implemented in Malawi, Zambia, Zimbabwe, Tanzania, and Mozambique. These countries exhibit a wide range of ISP approaches and distribution modalities. We pay particular attention to beneficiary numbers, targeting criteria, program objectives, input packs, distribution modalities, and costs.

Table 1 summarizes important attributes of ISPs in the study countries, bearing in mind that these figures vary year to year because of changes in global fertilizer prices, variations in targeting criteria, and implementation modalities, among other things. For many countries in the region, ISPs are arguably the cornerstone of agricultural public policy, collectively providing fertilizer and improved seed to millions of farmers. These programs focus primarily on raising cereal production and feature a limited range of fertilizer types. Most, however, also provide subsidies for legumes and small grain seed, and rice in the case of Tanzania. The utilization of the private sector in African ISPs varies, with traditional government run systems increasingly challenged by more market smart approaches. ISP expenditures in these countries often exceeding \$100 million per year and absorb a significant share of agricultural budgets (Jayne and Rashid 2013).

3.1. Malawi

The Government of Malawi has implemented various types of ISPs in most years since independence in 1964. The famous Starter Pack Program was in place from 1998/99 to 1999/00. The Starter Pack was developed in response to recommendations by the Malawi Maize Productivity Task Force, which had been established to explore policy options for addressing the country's chronic national food shortages. The task force identified declining soil fertility and low maize productivity as two major contributors to the food shortage problem. The Starter Pack was a universal subsidy for smallholders, entitling all farmers to 15 kg of inorganic fertilizer, 2 kg of hybrid maize seed, and 1 kg of legume seed for free; the maize inputs were sufficient to plant approximately 0.1 ha of maize (Druilhe and Barreiro-Hurlé 2012). The Starter Pack distributed these input packages to nearly all of Malawi's roughly 2.8 million households per year. The program objective of the Starter Pack was to kick-start agricultural growth by promoting low-risk technology adoption. Social protection was not a principal objective of the program (Dorward and Chirwa 2011).

Maize production increased substantially during the Starter Pack years, yet high fiscal cost, negative effects on the development of private sector input markets, and late delivery led to considerable donor opposition. In particular, in response to IMF pressure to reduce expenditure, the program was scaled down and transformed into a targeted subsidy program aimed more explicitly at providing support to poor smallholder households.

Known as the Targeted Inputs Programme (TIP), this *targeted version of the Starter Pack* operated between 2000/01 and 2004/05. The number of beneficiaries of the TIP varied year to year from a low of 1.5 million households in 2000/01 to a high of 2.8 million in 2002/03 following the drought induced food crisis of 2001. For most of the program's lifespan, the input packet of the TIP was the same as the Starter Pack, but this was increased to 25 kg of fertilizer, 5 kg of open pollinating variety (OPV) maize seed and 1 kg of legume seed in its final program year.

Table 1. Summary of ISPs in CSAP Target Countries

Country	Current beneficiary # (hhs)	Cost (million US\$)	Share of Ag. Budget (%)	Share of National Budget (%)	Fertilizer types and quantities (per/hh)	Staple food seed type and quantities (per/hh)	Non-staple seed type and quantities (per/hh)	Inclusion of other inputs (y/n)	Utilizes private agro-dealers (y/n)
Malawi MFISP	1.5 million	126.8 (2014/15)	52 (2014/2015)	6.5 (2010/2011)	50 kg NPK 50 kg urea	5 kg hybrid maize or 8 kg OPV	3 kg soy or 2 kg bean, cow pea, pigeon pea or groundnut	none	Yes (for seed only)
Zambia ZFISP traditional	1 million	113.2 (2013/2014)	30.2 (2013/2014)	1.9 (2013/2014)	100 kg Compound D 100 kg urea	10 kg maize	Small quantities: Groundnuts Sorghum and Rice	None	No
Zambia ZFISP e-voucher (piloted in 2015/16)	217,000	25	~ 6	Minimal	Variable	Variable	Variable	Yes	Yes
Zambia Food Security Pack	15,000	~4.1 (2012)	1.4	Minimal	25-50 kg compound D 25-50 kg urea	5 kg maize Or Sufficient seed to plant 0.5 ha of rice, sorghum or millet	Sufficient to plant 0.25 ha legumes (groundnuts, cow peas or beans) or cassava cutting	Yes (expanded Food Security Pack)	No (extended pack yes)
Tanzania NAIVS	1 million	104 (2011)	21 (2011)	N/A	50kg urea 50kg DAP or 100kg MRP	10kg hybrid or OPV maize or 15kg rice	None	No	Yes
Zimbabwe Gov't run	1.2 million	72 (2010/11)	38 (2010/11)	NA	50 kg urea 50 kg compound D	10 kg hybrid maize 5 kg small grain	Limited quantities of cowpea, sunflower, sugar beans	Yes (25 kg lime)	No
Zimbabwe Donor funded	320,000	90 (2012)	NA	NA	Variable	Variable	Variable	Yes	In some cases
Mozambique	20,000	NA	1	NA	NA	Maize Or rice	None	None	No

Source: information assembled from a wide range of sources including government program documents, Jayne and Rashid (2013); Ricker-Gilbert, Jumbe, and Chamberlin (2014); Mason 2013; Moyo, Chambati, and Siziba 2015; Dorward and Chirwa 2011; Lunduka, Ricker-Gilbert, and Fisher 2013; ZMAL 2015a. In 2005/06, the TIP was transformed into the Farm Input Subsidy Programme (MFISP, also known as the Agricultural Inputs Subsidy Programme). This is the program currently operating in Malawi today. The program's core objectives are similar to those of the TIP: improve household national food security, food self-sufficiency, and incomes by increasing resource-poor smallholders' access to improved agricultural inputs (Dorward and Chirwa 2011; Lunduka, Ricker-Gilbert, and Fisher 2013; Kilic, Whitney, and Winters 2015). N/A= Not Available

The primary distinguishing feature of the MFISP is its use of paper, and on a limited scale electronic vouchers to distribute inputs to farmers. Vouchers (or coupons as they are often called) are redeemable at different locations depending on the input type. Fertilizer vouchers are redeemed at government-run outlets (Agricultural Development Marketing Corporation (ADMARC) and Smallholder Farmers Fertilizer Revolving Fund of Malawi (SFFRFM) locations. Thus, although private firms are relied upon to import fertilizer, private firms in most years have not been involved in the distribution of fertilizer to farmers under MFISP. Conversely, seed vouchers can be redeemed at registered, private agro-dealers' shops (Logistics Unit 2015; Kilic, Whitney, and Winters 2015).

Until 2013/14, all MFISP coupons were paper, but an electronic voucher (e-voucher); scratch-card based system was piloted for seed in six Extension Planning Areas (EPAs) in 2013/14 and expanded to 18 EPAs in 2014/15. Fertilizer e-vouchers were piloted in 2014/15 in the six EPAs where seed e-vouchers had been piloted in 2013/14 (Logistics Unit 2015). The fertilizer e-voucher was to be expanded to eight districts and used to distribute 30,000 of the 150,000 metric tons of fertilizer intended for the 2015/16 MFISP.

The number of smallholder farm households that MFISP aims to reach has varied over time, but has been 1.5 million per year during the three agricultural years, 2012/13 through 2014/15 (Logistics Unit 2015). As of 2014/15, beneficiary farmers were to each receive vouchers for fertilizer, maize seed, and legume seed as follows:

- Two fertilizer vouchers: one for a 50 kg bag of NPK as basal dressing, and one for a 50 kg bag of urea as top dressing. When redeeming their vouchers for the fertilizer, farmers had to pay a MK500/50 kg bag top-up fee.
- One maize seed voucher for 5 kg of hybrid maize seed or 8 kg of OPV maize seed for free, although seed companies could apply a discretionary top-up fee of MK100 on the voucher.
- One legume seed voucher for 3 kg of soybean seed or 2 kg of other legume seed (beans, cowpeas, pigeon peas, or groundnuts) for free (Logistics Unit 2015).

However, under mounting fiscal pressure, the government recently announced that the farmer contribution to the MFISP would be increased substantially. As of August 2015, farmers are expected to contribute MK3,500 per 50 kg bag of fertilizer, and MK1,000 and MK500 for maize and legume seed, respectively. This decreases the subsidy rate from 90-95% to around 70%, and raises some concerns about access for low-income households.

In terms of beneficiary selection, the program relies on a three-step process. First, the Ministry of Agriculture and Food Security (MoAFS) allocates coupons to districts in proportion to their number of farm households. Second, within each district, the District Commissioner, in conjunction with the District Agricultural Development Officer, traditional authorities, NGOs, and religious leaders determine how to allocate the district's coupons to Extension Planning Areas (EPAs) within the district, and to villages within the EPAs. And third, within each village, beneficiary village residents are to be selected through community-based targeting in open forums. In general, MFISP beneficiaries are to be full-time smallholder farmers who cannot afford one or two bags of fertilizer at commercial prices (SOAS 2008). Priority is to be given to resource-poor households (e.g., those with elderly, HIV-positive, female, child, orphan, or physically-challenged household heads or household heads that were taking care of elderly or physically-challenged individuals) (Kilic, Whitney, and Winters 2015).

Table 2. Malawi Farm Input Subsidy Programme (MFISP) Cost 2005/06-2014/15

Cropping year	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
Total program cost (US\$ million)	55.7	88.6	114.6	274.9	114.6	127.4	151.2	207.0	168.2	126.8
Total cost as % of agricultural budget	N/A	61	61	74	62	61	52	38	53	52
Total cost as % of national budget	5.6	8.4	8.9	16.2	8.2	6.5	NA	NA	NA	NA

Sources: Lunduka, Ricker-Gilbert, and Fisher (2013), Dorward and Chirwa (2011), and Logistics Unit (Various Years).

Notes: NA = information not available. All redemption prices converted from MK to US\$ using the official exchange rate per World Development Indicators. For 2011/12 through 2014/15, program costs exclude government operational costs and voucher printing, and do not reflect funds recuperated through farmers' top-up fees.

Program costs are summarized in Table 2. Overall, the cost of the MFISP is substantial. In dollar terms, the implementation costs range from US\$55-275 million, depending on prevailing global fertilizer costs and beneficiary numbers. This constitutes 38-74% of total agricultural budget for the country and as much as 16.2% of the total national budget.

3.2. Zambia

Like Malawi, Zambia has a long history of input subsidy programs. Since 2002, the Zambian government has operated two ISPs. The largest of these is the Farmer Input Support Programme (ZFISP), which was originally called the Fertilizer Support Programme. ZFISP has operated since 2002/03 and is run by the Ministry of Agriculture. The Food Security Pack Programme is a substantially smaller ISP implemented by the Ministry of Community Development, Mother and Child Health since 2001. We provide details on both of the programs below.

3.2.1. Farmer Input Support Programme, 2002/03-present

The ZFISP emerged as a response to the massive drought that affected much of southern African in 2001. It was originally envisaged as a temporary program aimed at reinvigorating production and asset accumulation by smallholders, but has grown over the course of 13 years to become a dominate feature of Zambia's smallholder agricultural policy landscape.

ZFISP is a targeted ISP, with its stated objective "to improve the supply and delivery of agricultural inputs to small-scale farmers through sustainable private sector participation at affordable cost, in order to increase household food security and incomes" (ZMAL 2015a, p. 6). In Zambia, as in Malawi, food security is routinely conflated with maize self-sufficiency. As such, ZFISP has focused most intently on providing subsidies for maize fertilizer and seed. In the early years of the program (2002/03-2008/09), participating farmers received 400 kg of fertilizer (200 kg each of compound D and urea), and 20 kg of hybrid maize seed at a 50% subsidy. The input pack size was halved to 200 kg of fertilizer and 10 kg of hybrid maize seed from 2009/10 onward.

Small quantities of rice seed were added to the program in 2010/11, and sorghum, cotton, and groundnut seed were added in 2011/12; in 2014/15 cottonseed was dropped and the groundnut seed quantity increased more than 10-fold (Table 3). Subsidy rates have varied over time, ranging from 50-79% for fertilizer, and 50-100% for seed (Table 3).

In terms of targeting, ZFISP seeks to target small-scale farmer (cultivating less than 5 ha) who are registered with the Ministry of Agriculture and are actively engaged in farming. In addition, beneficiaries must be members of a farmer organization that had been selected to participate in ZFISP (which entails a host of membership fees as documented by Burke, Jayne, and Black 2012) and cannot be concurrent beneficiaries of the Food Security Pack Programme. They also needed to have the financial means to pay the farmer share of the input costs (e.g., approximately US\$65 total for 200 kg of fertilizer and 10 kg of hybrid maize seed in 2014/15). In previous years of the program, there was also a requirement that beneficiaries have the capacity to cultivate a minimum area of land (e.g., 1 ha in 2012/13).

Beneficiary selection is done by Camp Agriculture Committees, which include representatives of the local chief, farmer organizations, other community based organizations, and public offices other than Ministry of Agriculture, which through the Camp Extension Officer, serves as the secretariat.

Under the traditional ZFISP, the government assumes responsibility for procuring inputs, transportation, storage, and distribution, either directly or through a tendering process. No vouchers are involved and agro-dealers are by-passed. Moreover, in recent years the parastatal Nitrogen Company of Zambia has provided all of the Compound D fertilizer requirements for the program. This has raised significant concerns about the effects of the ZFISP on private sector input supply system development.

In response to these concerns, Zambia began piloting an electronic voucher under its FISP in 2015/16. The e-voucher pilot utilizes a visa swipe card system to enable beneficiaries to redeem the vouchers at a variety of identified agro-dealer shops. In total 217,123 beneficiaries have been identified, using the same identification strategies as the traditional FISP. These beneficiaries are located in the 31 districts along the *line of rail*. In total, 204 agro-dealer shops have been identified to participate. The voucher provided to beneficiaries is valued at approximately \$160 and is redeemable for a wide range of agricultural inputs and equipment (e.g. backpack sprayers). The total implementation cost is US\$25 million (ZMAL 2015b).

As shown in Table 3, in total the ZFISP (both traditional and e-voucher) currently targets 1 million smallholder households. This number is likely to increase given the upcoming elections in Zambia in August 2016. Implementation costs vary depending on prevailing input costs and beneficiary numbers. As shown in Table 3, since the program was expanded in 2009/10 implementation costs have ranged from \$113 to \$184 million, or 30 to 50% of the total agricultural budget. This is equivalent to 2 to 4.4% of the total national budget.

Table 3. Key Features of the Zambia Farmer Input Support Programme (ZFISP), 2002/03-2014/15

Cropping year	Number of intended beneficiaries	Quantities of subsidized inputs (metric (ton))					Fertilizer subsidy rate (%)	Seed subsidy rate (%)	Total program cost (US\$ million)	Total cost as % of agricultural expenditures	Total cost as % of national expenditures
		Fertilizer	Maize seed	Rice seed	Sorghum seed	Ground-nut seed					
2002/03	120,000	48,000	2,400	0	0	0	50	50	4.04	10.4	0.5
2003/04	150,000	60,000	3,000	0	0	0	50	50	10.56	17.2	1.1
2004/05	115,000	46,000	2,500	0	0	0	50	50	20.52	26.8	1.6
2005/06	125,000	50,000	2,500	0	0	0	50	50	31.36	26.9	1.9
2006/07	210,000	84,000	4,234	0	0	0	60	60	51.08	25.5	2.4
2007/08	125,000	50,000	2,550	0	0	0	60	60	51.10	18.0	2.2
2008/09	200,000	80,000	4,000	0	0	0	75	50	131.37	37.6	3.5
2009/10	500,000	100,000	5,342	0	0	0	75	50	111.99	42.5	3.7
2010/11	891,500	178,000	8,790	30	0	0	76	50	122.78	29.9	3.4
2011/12	914,670	182,454	8,985	39	0	0	79	53	184.21	30.1	4.4
2012/13	877,000	183,634	8,770	143	60	150	--	--	165.68	50.3	3.1
2013/14	900,000	188,312	9,000	159	107	130	50	100	113.22	30.2	1.9
2014/15	1,000,000	208,236	10,000	127	119	1,357	--	--	--	--	--

Sources: ZMAL (2015 various years), ZMFNP (various years).

Notes: Information not available. Input quantities rounded to the nearest metric ton.

3.2.2. Food Security Pack Programme, 2000/01-Present

The Food Security Pack Programme is intended to target farmers that do not have the resources to pay the ZFISP farmer contribution or, when there was a minimum land requirement for ZFISP participation, farmers that could not meet it. More specifically, the Food Security Pack Programme targets ‘vulnerable but viable’ farmers, whom it defines as households with less than one hectare of land, adequate labour, not in gainful employment, and being headed by someone who is either female, a child/youth, elderly, terminally ill, or caring for orphans or disabled individuals (PAM 2005). In addition, participating farmers are trained in conservation farming techniques and are required to prepare their field(s) using these practices (ibid.). Community Welfare Assistance Committees or Area Food Security Committees select program beneficiaries.

The contents of a Food Security Pack vary by agro-ecological region but generally consist of seed and fertilizer to plant 0.5 ha of cereals (maize, rice, sorghum, or millet), legume seed for 0.25 ha, sweet potato vines or cassava cuttings, and, in areas with acidic soils, 100 kg of lime. Fertilizer quantities are either 50 or 100 kg depending on the cereal seed received (ibid.). The objective of the program is “to empower the targeted vulnerable but viable households to be self-sustaining through improved productivity and household food security and thereby contribute to poverty reduction” (PAM 2005, p. 1). Beneficiaries are not required to make a cash contribution for the Food Security Pack inputs; rather, they pay in-kind a fraction of the value of the inputs received (e.g., 100 kg of maize for those receiving input packs containing maize seed).

The scale of the Food Security Pack Programme has generally been much smaller than ZFISP. While at its peak in 2003/04 it reached 145,000 households, nearly as many as ZFISP, by the late 2000s and early 2010s the Food Security Pack Programme only received enough funding to reach about 15,000 households per year (compared to 900,000 under ZFISP).

Although small, the Food Security Pack Programme has been considerably more innovative than ZFISP. For example, it has taken a more holistic approach to raising smallholder productivity and incomes by including a significant extension component (training farmers in conservation farming) and by including inputs other than just maize seed and fertilizer. In addition, since 2012/13, it has piloted in three districts an *Expanded Food Security Pack Programme*, which utilizes e-voucher scratch cards redeemable at private agro-dealers’ shops for the aforementioned inputs and a Chaka hoe, a specialized hoe designed for digging planting basins, the hand-hoe variant of conservation tillage promoted in Zambia. The program also includes a social cash transfer component: each beneficiary household receives ZMW100 (approximately US\$16.25 in 2014) in January, near the peak of the lean season and when school fees are due. The Expanded Food Security Pack Programme has been funded by the Royal Norwegian Embassy in Lusaka; the pilot is due to end after the 2015/16 agricultural season, by which time the program hopes to have reached 27,000 total households. Discussions are underway to determine if the Ministry of Community Development, Mother and Child Health will adopt and roll out the Expanded Food Security Pack Programme model to other districts in Zambia after the pilot ends.

3.3. Tanzania

Tanzania re-introduced an agricultural input subsidy program in 2003/04. Initially the program was quite small, both geographically and in terms of beneficiary numbers (although exact numbers are unavailable). The initial program allowed private input supply companies to tender for particular geographic areas. The winning firms were allocated fertilizer and seed by the government at fixed prices. These inputs were then distributed to farmers by the private firm. The fixed prices at which the

private firms purchased fertilizer at regional depots were below market price. In addition, transport costs were covered by the government as part of the subsidy. The program ended, however, in 2007/08 based on the conclusion that private traders were not passing along the full subsidy to targeted smallholder farmers. It was difficult for government to monitor this because fertilizer was also selling in rural areas through commercial markets, and hence it was difficult to ascertain whether prices paid by farmers were for commercial or subsidized fertilizer.

In 2008/09, this program was replaced by the National Agricultural Inputs Voucher Scheme (NAIVS). NAVIS provided subsidy support for maize and rice production. The program was launched in 56 districts, but because food prices remained high and volatile in the aftermath of the world food price rise, the program was expanded in 2009 to 65 districts, with the intention to run for five years (four of which were funded by the World Bank). The NAIVS ended after the 2013/14 farming season when external financing from the World Bank ended. It was reintroduced, on a substantially smaller scale using government funding in 2015/16. It is unclear how many beneficiaries it reached in 2015/16.

The NAIVS is implemented through a voucher system and has the overall program objectives of (i) improving farmers' access to modern inputs; (ii) creating awareness to farmers about the benefits of using fertilizer; and (iii) improving crop productivity for the main staple food in the target area (either maize or rice).

Beneficiary farmers are provided three vouchers through the NAIVS: (1) one for one 50 kg bag of urea; (2) one for a 50 kg bag of Di-Ammonium Phosphates (DAP) or two 50 kg bags of Minjingu Rock Phosphate (MRP) with nitrogen supplement (farmers were supposed to choose); and (3) one for 10 kg of hybrid or open-pollinated maize seeds or 15 kg of rice seeds, sufficient for half a hectare of maize or rice. These vouchers are redeemable at private agro-dealer shops. It was planned that vouchers for each input had a face value equivalent to 50% of the market price of the respective input, with the remaining 50% to be paid by the farmers. However, the actual subsidy level varied between years depending on the price of fertilizer. Agro-dealers then submit the vouchers to the District Agricultural and Livestock Development Officer for approval and then submit them to the appointed bank for redemption.

In total 3,855 agro-dealers were utilized by NAIVS. In addition, these agro-dealers were trained on appropriate methods of fertilizer use, in an effort to improve farmers' access to information on proper fertilizer application (World Bank 2014).

In terms of targeting, beneficiaries are selected according to the following criteria: (1) are able to co-finance the inputs purchased with the voucher; (2) are literate; and (3) do not cultivate more than 1 ha of maize and/or rice; with priority to be given to female headed households and households who have used little or no modern inputs on maize or rice. These criteria reflect the implicit dual objective of the program: (1) increase overall maize and rice output (e.g. by focusing on non-input using, literate farmers who are more likely to have a higher marginal productivity); and (2) increase access to modern inputs among poor and vulnerable smallholders (e.g. by giving priority to female-headed households). In general terms, the objective was to provide access to these inputs for a period of three years, in order to encourage adoption and, ultimately, to contribute to sustained productivity gains.

Each beneficiary household is expected to receive the subsidy for a period of three years only, with the expectation that after this period the household is able to engage with input markets without subsidy support. Total beneficiary numbers for the period 2008/09 to 2013/14 are summarized in Table 4.

Table 4. NAIVS Beneficiary Numbers

	2008/09	2009/10	2010/11	2012/13	2013/14
Beneficiaries	735,000	1,500,000	2,000,000	1,800,000	932,000

Source: NAIVS.

The modalities of fertilizer distribution under the NAIVS are described as follows by Pan and Christiaensen (2012). “The central government allocates the vouchers to the target regions, which subsequently distribute it to their districts, which in turn distribute it to the villages in their district. At each level of government a special voucher committee is set up to allocate the vouchers to the lower levels based on the expected demand for inputs using historical production data for maize and rice as well as other related information such as the number of smallholder farmers who grow maize and rice and the average land size per farmer. The last step in the distribution is at the village level. First, the village council, in consultation with the village assembly organizes the election of the Village Voucher Committee (VVC), which should consist of three men and three women. Then, the VVC draws up a list of beneficiary farmers for approval by the village assembly. After approval, the VVC issues the vouchers to the approved farmers, who can redeem them with local agro-dealers participating in the program.”

Identified program challenges for NAIVS include: (i) input requirements are higher than what the government can afford, indicating that the government is unable to continue a large-scale program without external assistance; (ii) some vouchers were distributed late under NAIVS, forcing households to apply fertilizer late and suffer some loss of yield as a result; (iii) payments to input suppliers participating in the program often occurred late and was a source of friction between private firms and the government; and (iv) maize output markets and trade was restricted at times by the Government of Tanzania, reducing maize prices received by farmers and hence depressing the value to farmers of the additional production due to NAIVS.

In terms of programme financing, the cost of implementing NAIVS is estimated at US\$92 to \$114 million per year. The World Bank covered half of this cost. This is equivalent to 21 to 53.5% of the country’s total agricultural budget.

3.4. Zimbabwe

Like Zambia, Zimbabwe’s recent experience with ISPs can be traced back to the regional drought that affected the countries in 1991. Since then, Zimbabwe has maintained some form of ISP in most years. In Zimbabwe, the government and development partners operate separate ISPs, both of which have evolved over time.

Government-run ISPs: Until 2009 the Government of Zimbabwe (GoZ) directed ISP support to all farmer categories, including commercial A2 farmers, who received subsidies for wheat and soybean production (Moyo, Chambati, and Siziba 2014).² However, beginning in 2009 the government’s focus shifted to the small-scale sector, including A1 farmers, communal land farmers, and old settlement scheme farmers. Currently the GoZ operates two ISPs: the Presidential Input Scheme and the Crop Input Scheme. Both of these scheme involve the physical distribution of inputs to beneficiaries, using parastatal infrastructure controlled by the Grain Marketing Board (GMB) and Agritex.

² A1 and A2 farmers are far categories developed as part of Zimbabwe’s Fast Track Land Reform (FTLR).

The input packages distributed under these schemes include: 10 kg hybrid maize seed; 5 kg small grains; 50 kg Ammonium Nitrate; 50 kg compound D and 50 kg lime. The Presidential scheme also includes seed for cow peas, sunflower, and sugar beans.

Beneficiary farmers are selected through multiple levels of committees, from National to Ward level. Ward level committees include councilors and village heads, who are ultimately responsible for selection. In total 1.2 million households are targeted under these two ISPs, at a cost of US\$37-72 million (Moyo, Chambati, and Siziba 2014). This amounts to roughly 13-38% of the total budget for agriculture, including donor support for public expenditures.

Donor-run ISPs: Donors play a significant role in ISPs in Zimbabwe. As of 2012 donor sponsored ISP facilities valued at US\$90 million (Hanyani-Mlambo et al. 2012). This supported 319,200 households with both crop and livestock inputs. In Zimbabwe a great deal of experimentation has been done with ISP distribution modalities, including the delivery of free inputs to farmers in the 1990s and early 2000s, closed vouchers redeemable at retail shops, and, more recently, open vouchers and electronic vouchers that are redeemable at retail shops (Moyo, Chambati, and Siziba 2014). Closed vouchers are commodity specific and comprise pre-determined inputs (seed and fertilizers), which varied by agro-ecological region and were packaged in line with GoZ recommendations. Open vouchers, on the other hand, have specific values depending on the donor agency (Hanyani-Mlambo et al. 2012). The open vouchers allow farmers to purchase inputs of their own choice from local agro-dealers within the limits of the monetary value of the vouchers. Open vouchers in Zimbabwe include both electronic vouchers, redeemed through point of sale machines or cellular network or internet, and manually paper vouchers.

Since 2011/12, some ISP vouchers distributed by donors have been bundled with conservation agriculture training. The training is conducted by the distributing agency (Moyo, Chambati, and Siziba 2014). The average value of the voucher in 2011/12 was US\$160.

It is important to note that donor ISPs do not target the high potential regions where Fast Track Land Reforms were carried out, and therefore are not intended to reach A1 or A2 farmers. The geographic focus of these ISPs is communal areas, which tend to be in more marginal agro-ecological regions.

3.5. Mozambique

Currently Mozambique has no ISP. Previously, NGOs provided inputs for a range of relief activities, with most of these providing inputs directly to farmers. In some cases, these programmes required payment in the form of grain. However, these programmes suffered from logistical challenges and have been discontinued.

In response to escalating food prices in 2008, Mozambique did briefly introduce a small and geographically concentrated program to boost maize and rice yields through on-farm demonstrations coupled with input subsidies. Known as PAPA (*Plano de Acção para a Produção de Alimentos*) this program lasted just two agricultural seasons 2009-11. In total about 20,000 smallholder farmers received subsidized input packages in five provinces in the centre and north of the country (Sitko et al. 2017). This amounted to roughly 1% of Mozambique's agricultural budget.

4. CAN ISPS PROMOTE *EX ANTE* RISK MANAGEMENT AT THE HOUSEHOLD LEVEL?

Having reviewed how ISPs are implemented in the various target countries, we now examine the ways in which these significant public investments can potentially be harnessed to foster more climate resilient and productive smallholder farm systems in the region. The sorts of management practices we examine are often associated with CSA or *sustainable intensification* (SI) and include tillage method, intercropping and rotations, the use of manures and residue retention, and agro-forestry. More broadly, we explore the potential relationship between ISPs and practices that can potentially stabilize and/or improve smallholder crop yields in the context of climate variability.

4.1. Review of Evidence to Date

This section reviews the evidence to date on how ISPs affect the use of inputs and management practices that may be climate smart. The evidence base remains thin but the weight of the available evidence suggests that *ISPs have had either no effect on or have reduced SSA smallholders' use of CSA practices*. More specifically, evidence suggests that in Ghana ISPs did not affect farmers' investment in soil and water conservation, broadly defined (Vondolia, Eggert, and Stage 2012), nor did they affect Malawian or Zambian smallholders' use of manure. And while Malawi's ISP had no statistically significant effect on intercropping (Holden and Lunduka 2010), Zambia's ISP has reduced intercropping in general, but not intercropping involving legumes (Levine 2015). Moreover, Zambia's ISP has negatively affected crop rotation and fallowing (ibid; Mason, Jayne, and Mofya-Mukuka 2013). The program has thus contributed to continuous cultivation of mono-cropped maize over time and within seasons in Zambia, all of which degrades soils, contributes to maize disease and pests, and leaves smallholders more vulnerable to climate shocks—the antithesis of CSA. ISPs increase maize yields in the short run except during extreme weather conditions (see Holden and Lunduka 2010; Mason, Jayne, and Mofya-Mukuka 2013; Chibwana et al. 2014; Mason et al. 2015; among many others), but if results similar to Zambia obtain elsewhere, in terms of decreasing fallows, increasing mono-cropping, and decreasing crop rotations, these yield gains could be coming at the cost of lower soil organic matter and higher soil acidity, both of which will result in lower yields and fertilizer use efficiency in the medium to long run (Marenya and Barrett 2009; Burke 2012). This is an important area for future research.

Empirical evidence on the effects of ISPs on crop diversification, another potential CSA approach, is more mixed. For example, while Chibwana, Fisher, and Shively (2012) and Mason, Jayne, and Mofya-Mukuka (2013) find that ISPs in Malawi and Zambia, respectively, incentivize households to devote a greater share of their cropped area to maize, other studies from Malawi suggest the opposite (Holden and Lunduka 2010; Karamba 2013) or that ISPs have no statistically significant effect on crop diversification (Karamba 2013).

Another feature of many ISPs that is decidedly *not* climate smart is perennial late delivery of subsidized fertilizer and seeds to beneficiary farmers (Xu et al. 2009; Lunduka, Ricker-Gilbert, and Fisher 2013; Mason, Jayne, and Mofya-Mukuka 2013; Namonje-Kapembwa, Jayne, and Black 2015). Late delivery can result for a variety of organizational and financial constraints, including limited financial capacity to import the full ISP fertilizer requirement at one time, delays in printing and distributing vouchers, delayed payments to transporters, among other issue. Late delivery is particularly common when ISP inputs are disseminated through state-run distribution systems that largely sideline the private sector rather than working through agro-dealers and other existing input distribution networks. This is how fertilizer for Malawi's ISP and both fertilizer and seed for Zambia's ISP were distributed until 2014/15 and 2015/16, respectively, when each country started piloting agro dealer-based voucher redemption systems (Logistics Unit 2015; ZMAL 2015a, 2015b). Late delivery of ISP inputs results in late planting

and/or late fertilizer application, reducing yields and leaving beneficiary households vulnerable to climate shocks (Xu et al. 2009; Namonje-Kapembwa, Jayne, and Black 2015; Arslan et al. 2015).

An important way in which ISPs can contribute to sustainable productivity growth is to maximize the efficiency with which farmers convert fertilizer into crop output. Efforts to promote a more efficient use of fertilizer will not only potentially support sustainable forms of agricultural intensification but also reduce the ratio of GHG emissions to food produced. However, the track record of ISPs on this issue has been disappointing. Jayne et al. (2016) conclude that most African governments to date have focused more on increasing African farmers' use of fertilizer than on providing support for its efficient use. Most public agricultural extension systems are seriously under-provisioned to perform their mandate of providing new management advice to farmers, learning from their efforts and difficulties in integrating such practices into their farming systems and liaising with adaptive research systems to generate and disseminate new productive and sustainable practices, including CSA practices. Some African public extensions are virtually defunct. Therefore, it should not be surprising that despite heavy spending on ISPs, their impacts on crop yields have been smaller than anticipated (ibid). In Zambia and Malawi, for example, a 1 kg increase in subsidized fertilizer raises smallholder households' maize output by an average of only 1.88 kg and 1.65 kg, respectively, (Mason, Jayne, and Mofya-Mukuka 2013; Ricker-Gilbert and Jayne 2011). This low crop yield response to fertilizer is a major reason for the relatively low benefit cost ratios of the ISPs in Malawi (1.08) and Zambia (0.92) (Jayne et al. 2013).

These findings pertain to ISPs as they have been implemented to date. As discussed, many ISPs are currently in the process of some level of transformation to more flexible, private-sector inclusive systems. This creates possibilities for ISPs to be restructured in ways that incentivize farmers to adopt particular CSA practices and bring about system-wide changes that promote resilience. The remainder of this section examines this potential of ISPs, realizing that the discussion is largely conjectural because there is limited evidence to draw upon to suggest that ISPs as implemented to date have achieved any such benefits.

4.2. Looking Forward: Can Input Subsidy Programs Contribute to Climate Smart Farm Management Practices?

A handful of *ex ante* analyses have explored how ISPs might compare to other programs to promote farmers' use of practices that may be climate smart. For example, Marenja et al. (2012) use 30-year crop simulation models for maize, rice, and sorghum calibrated for several districts in Kenya, Malawi, and Uganda to compare changes in the net present value (NPV) of adopting various soil fertility management (SFM) strategies under two sets of policy regimes: a 50% fertilizer subsidy and carbon credits priced at \$4, \$8, or \$12 per metric ton of carbon sequestered in the soil. The SFM strategies considered include various combinations of inorganic (N) fertilizer, animal manure, and crop residue retention—practices that may help to increase and stabilize yields in some agro-ecological contexts. Their results suggest that carbon credits, especially when priced at \$8 or \$12/metric ton, produce larger NPV increases than the 50% fertilizer subsidy. While carbon markets are virtually non-existent in Africa, this analysis suggests monetary incentives play an important role in stimulating adoption of practices that may be climate smart. Thus, there may be scope to transform ISPs in ways that deliver monetary incentives to promote farm management behavioral changes. Yet, this in turn requires that extension systems are capable of delivering appropriate management information and that adoption is effectively monitored, which on the face of it seems very challenging.

In later work, Marenja, Smith, and Nkonya (2014) use choice experiments to measure Malawian smallholder farmers' preferences for various hypothetical policy incentives to adopt soil conservation practices aimed at improving long-term soil characteristics (and therefore, potentially being climate

smart): cash payments, two different types of index-based crop insurance contracts, and fertilizer subsidies.³ The specific soil conservation practices being incentivized were minimum tillage combined with intercropping maize with an unspecified leguminous shrub; again, these practices may be ‘climate smart’ in some contexts. Based on the levels of the policy incentives used in the choice experiments, results suggest that most farmers preferred fertilizer subsidies to cash payments or crop insurance. In addition, farmers generally preferred cash payments to crop insurance, even when the expected pay out from the crop insurance was higher than the cash payment. We must be careful, however, in generalizing these results, as they are specific to the choice sets used in the experiments. For example, the fertilizer subsidy preference over cash payments could be driven by the levels of cash payments that were compared to the fertilizer subsidy: the fertilizer subsidy option (MK 2,000) first order stochastically dominated all of the cash payment options (ranging from MK 800 to MK 2,000) used in the experiment due to the yield gains that farmers could expect with the fertilizer. In both cases, however, this analysis suggests that under the right conditions some combination of conditional subsidy or conditional cash payment can incentive adoption of farm management practices. Whether or not this leads to a permanent behavioral change, or whether public entities are capable of monitoring adherence to the conditions remains an open question.

The effects of ISPs on farm-level cropping mix likely depend on the range of inputs provided. ISPs that focus less on a specific crop and support a broader range of alternative crops, in particular legumes, may generate better outcomes with respect to crop diversification and soil fertility. Research from Malawi shows that a 3-year rotation involving pigeon pea intercropped with another legume in year 1, maize intercropped with pigeon pea in year 2, and mono-cropped maize in year 3 can significantly raise soil organic carbon over time, better retain soil moisture during periods of drought stress, raise the agronomic efficiency of inorganic fertilizer use, and obtain higher maize production over the 3-year period using less inorganic fertilizer than standard techniques depending on high levels of nitrogen input (Snapp et al. 2010; Snapp and Fisher 2015). Perhaps in growing recognition of the importance of incorporating leguminous crops into smallholder production systems, the ISPs in both Zambia and Malawi have recently added significant quantities of legume seed to their programs. For example, in 2014/15, the Zambia program distributed 1,357 metric tons of groundnut seed (and 10,000 MT of maize seed) (ZMAL 2015a), and the Malawi program distributed 3,027 metric tons legume seed (and 8,434 metric tons maize seed) (Logistics Unit 2015).⁴ These program innovations have the potential to increase the returns on public investments in ISPs and may promote increased crop diversification, or crop rotation or intercropping of maize with legumes.

Finally, there is the question about whether raising crop productivity through fertilizer use might reduce the rate at which forests are converted into farmland, and therefore, reduce the agricultural sector’s contribution to GHG emissions. Recent evidence has begun to question the logic that agricultural productivity growth can arrest rapid farm area expansion and thus conserve the world’s forests and grasslands (Hertel 2011; Headey and Jayne 2014; Byerlee, Stephenson, and Villoria 2014). Instead, by virtue of a generally positive area response to improved profit incentives, strategies that make farming more profitable per unit land are likely to create new pressures for conversion of forest and grasslands to farmland. Policy incentives could play a potential role here. In theory, ISPs could be structured in such a way as to oblige beneficiaries to reduce or maintain the amount of area under cultivation. However, it is not clear whether such rules would impose unreasonable demands on food insecure rural households or whether they could be adequately monitored or enforced. ISPs provided to communities

³ Farmers also had the option to decline the soil conservation incentives in favour of continuing traditional practices, which in the context of the choice experiments were defined as not using chemical fertiliser or the soil conservation practices.

⁴ Malawian ISP beneficiaries were each to receive improved maize seed (5 kg hybrid or 8 kg OPV) and improved legume seed (3 kg soybean or 2 kg of beans, cowpeas, pigeon peas, or groundnuts) (Logistics Unit 2015).

conditional on tree planting for sustainable management of 5-10 hectare community woodlots might be more easily monitored; Mbow et al. (2014) argue that community woodlots could be an effective way of conserving forest land.

In summary, while ISPs can be theoretically structured in ways to promote farm-level management changes, the oversight, enforcement, and extension costs needed to make this work are high. The high level of public expenditures on ISPs, therefore, come at significant opportunity costs to effectively linking them to changes in farm management practices.

4.3. How Confident Are We that We Know which Farming Practices Contribute to CSA and Sustainable Intensification?

As the development community understandably pushes hard to make progress in helping African farmers be less vulnerable to increasing climate variability, there are major risks of overgeneralization about what kinds of farming practices really contribute to *ex ante* resilience and *ex post* mitigation. Africa is heterogeneous with respect to its climate conditions, soil types, market access condition, and factor price ratios. Some parts of Africa are still land abundant; labour and capital may be binding constraints in such areas. Other agricultural areas of Africa are densely populated, facing land pressures and rising land prices. In some of these areas, labour is relatively abundant and hence labor-intensive CSA practices may hold some potential to be scaled-up and incentivized through ISPs. However, in areas with good market access conditions and close to urban areas, economic transformation processes are bidding up labour wages and making it difficult for farmers to adopt labor-intensive CSA practices unless they also provide high returns to labour. The heterogeneous conditions of farming systems in Africa warrant great caution against overgeneralization in promoting technologies through ISPs or on their own based on blanket recommendations across wide domains.

Take conservation and no-till farming for example. Minimizing soil disturbance through no or minimum tillage (MT)⁵ strategies are frequently promoted in Africa as a means to mitigate soil erosion, increase soil water retention capacity, and to slow the rate of soil organic carbon (SOC) decomposition, and thus achieve yield growth and stability (Branca et al. 2011; Chivenge et al. 2007). However, yield and soil quality effects of MT practices vary substantially depending on soil type and slope, and association of MT with other land management practices, namely crop residue retention and incorporation. Several studies have shown that MT practices lead to an accumulation of SOC in the surface layers of soil (0-10 cm), rather than in the root zone (Sisti et al. 2004; Chivenge et al. 2007; Carter and Rennie 1982; Hernanz et al. 2002; Doran 1980). Carter and Rennie (1982) find that microbial biomass and potential mineralizable carbon and nitrogen are high in surface soils where MT is practiced. Conversely, these soil properties are higher in lower soil depths when conventional tillage (CT) is applied. This matters, because the magnitude of the SOC pool and its location in soil strata are important for yield growth and stabilization. As Lal (2006) shows, every 1 metric ton/ha increase in the SOC pool in the root zone is associated with a 30–300 kg/ha increase in maize yields and a 10–50 kg/ha increase in rice yields.

Management practices that improve the SOC pool in the root zone can simultaneously enhance soil's water retention capacity (Mbagwu 1991; Fernández-Ugalde et al. 2009); increase its cation exchange capacity, and thus nutrient retention (Carter et al. 1992); and improve soil aggregation and susceptibility to erosion (Lal 2006; Paul et al. 2013).

⁵ In this section we present evidence on both zero and minimum tillage methods, which we will refer to broadly as minimum tillage.

Thus, as some studies show, without associated investments in crop residue retention and/or crop rotation, fields tilled using MT frequently experience no yield improvement (Hernanz et al. 2002) or in some cases a dramatic drop in yield relative to CT (Rusinamhodzi et al. 2011; Raimbault and Vyn 1991; Paul et al. 2013). When MT practices are applied in conjunction with crop residue retention, legume rotation, and/or nitrogen fertilizer application, the yield effects of MT tend to be higher than those achieved through CT, but again this is highly dependent on prevailing agro-ecological conditions (Raimbault and Vyn 1991; Govaerts, Sayre, and Deckers 2005; Dalal, Henderson, and Glasby 1991; Triplett, Van Doren, and Schmidt 1968). While practices such as residue retention, inorganic fertilization, and manuring do offer potential yield benefits independent of other practices, evidence suggests that in many cases the combination of practices is needed to maximize returns to a particular activity.

As discussed in Section 3, many ISPs in the region are not designed to cope with the high level of regional and farm level heterogeneity in input needs and requirements. Instead, they tend to focus on a uniform set of inputs, as this is easier to procure, manage, and implement. To make ISPs more effective at promoting CSA objectives, there is need for greater region-specific composition of ISP inputs. More importantly, input distribution needs to be coupled with region-specific farm management promotion strategies in order to more effectively link ISPs to the attainment of CSA goals. This implies significant modification in the logistical design, implementation, and cost of ISPs.

A more obvious way in which ISPs can influence overall productivity is through the injection of greater levels of nitrogen (N) into African soils (where nitrogen is the most limiting nutrient for plant uptake in most of the region). Massive injections of N may kick start a beneficial process of biomass generation and soil quality improvements needed to sustain yield growth and generate returns to other management practices. However, the challenge of promoting effective CSA approaches through large-scale programs, such as ISPs, is complicated by the fact that managing carbon together with nitrogen is necessary to achieve high nitrogen efficiency in agriculture (Tittonell and Giller 2013). Reliance on inorganic fertilizer alone, no matter how good the precision technology employed, will only allow about 50% of whatever nitrogen is applied to be taken up by the plant, as crop yield response requires a large inorganic nitrogen pool (i.e., major additions of N fertilizer each year to obtain an appreciable crop response). Rusinamhodzi et al. (2011) in their summary of evidence on conservation agriculture shows that in 73 percent of the field studies, high levels of nitrogen fertilizer application were required to achieve improved yields under these practices. Maintaining a large enough N pool for crop response is especially costly in soils of low soil organic carbon, because these soils are inherently *leaky*, in that nitrogen will mostly leak out of the soil primarily through leaching but also through gaseous loss pathways, and thus require high levels of nitrogen application for appreciable crop response (Drinkwater and Snapp 2007), which tend to be beyond the reach of many smallholder farmers.

Paul et al. (2013) demonstrate that without sufficient biomass production (often stimulated by inorganic fertilizer application), CSA practices of MT and residue retention do not have an effect on yield stability or SOC. However, recent advances in soil science and agronomy research show that massive nitrogen (N) injections may not be economically feasible for farmers or be social welfare raising without farmer adoption of complementary soil management practices that allow N to be efficiently utilized by plants. While the application of inorganic fertilizer does help to raise yields in low yield farming systems, the magnitude and economic sustainability of the yield response is in many ways contingent on complimentary improvements in soil characteristics.

Unfortunately, large-scale efforts to promote practices that build up soil organic carbon are largely absent from government programs, are untested over the wide range of soil types and agro-ecologies

found in the region, and are sometimes discounted by some as not being viable from the standpoint of low-resource farmers.

These several examples underscore the lack of consensus within the crop science community about what viable CSA and SI packages appropriate for heterogeneous smallholder agricultural systems should look like. For these reasons, we conclude that African governments and the development community need an improved scientific/soil science evidence base that establishes the practices that actually promote CSA objectives under the wide range of diverse farming conditions found in the region. A precondition for making progress on this front is much greater public expenditure on agricultural R&D and adaptive research across the various economic/biophysical microclimates that African farmers operate in. While necessary, increased public funding to agricultural R&D is not sufficient. However, without a better evidence base on what practices work well/not well under which conditions, the risk is that ISPs can aim to promote practices believed to promote CSA and/or SI which may not do so and which may impose additional burdens on smallholder farmers in the process.

5. CAN ISPS PROMOTE SYSTEM-WIDE EX ANTE RISK MANAGEMENT?

Thus far, we have focused most intently on the capacity of ISPs to serve as a vehicle for the adoption of farm level practices that can potentially lower farmer's income and livelihoods risks to climate change. This section examines the potential of ISPs to encourage system-wide changes in agricultural value chains that promote resilience to risks associated with climate variability. Due to their scale, ISPs may have greater capacity to influence the broader systems within which farmers operate and thereby influence farmer behavior both directly as well as indirectly through system-wide changes. We identify three potential areas where these system-wide effects are most evident.

5.1. Potential Opportunities

First, by expanding and stabilizing the demand for specified input types and quantities, ISPs can potentially help to overcome some of the persistent risks associated with the commercial production of certain seed types. This includes OPVs, which may have limited commercial appeal, and most legume seeds, which are notoriously hard to forecast demand for. Supporting demand for these seed types through ISPs can help firms to better plan investments in multiplication and smallholder distribution, thereby helping to address systemic constraints to achieving crop diversification, organic nitrogen fixation, and rotations. However, this potential benefit is diminished by the trend, among donors and governments, to move toward open voucher systems. Thus, in many ways there are important trade-offs to consider when promoting particular ISP distribution modalities. While open vouchers are desirable from a farmer choice perspective, restricted-choice vouchers for particular inputs, such as legume seeds, may be necessary to support system-wide improvements in legume seed supply chains. Restricted-choice vouchers may be justified in some instances where there are major beneficial externalities associated with promoting certain inputs.

Similar system-wide benefits may accrue by using ISPs to create farmer demand for specific drought-tolerant seed varieties or soil amendments such as lime or inoculants, which are currently not widely used by farmers. As with legume seeds, promoting the utilization of these inputs may require using restricted rather than open voucher systems.

A second way in which ISPs may promote system-wide CSA resilience is through promoting market smart private investments. The tendency to move toward more market-friendly ISPs may help to promote greater private investments in input supply chains, and in some cases private extension services, which will help to further the CSA objective of sustainably improving and stabilizing yields. By encouraging private sector input supply chain development, market-friendly ISPs can foster improved input access conditions for farmers, thus over time making them less dependent on public input supply systems. Private input systems may be less prone than public systems to delivery challenges associated with logistical and financial constraints. However, there is concern about the capacity of market smart ISPs to effectively serve outlying and low agricultural potential regions. Nonetheless, there seems to be clear potential for ISPs to promote system-wide investments that are both climate smart and market-smart and synergistic in their promotion of community resilience to climate variability.

Finally, the move toward digital platforms for delivering ISPs, such as e-vouchers, creates opportunities to use ISPs as delivery mechanisms for other sorts of products, such as weather indexed insurance. This requires that ISP farmer registries collect a wide range of information on beneficiaries, including geographic location and bank information. With this sort of information, ISPs can defray the screening costs of identifying farmers and managing insurance payouts when necessary.

5.2. Potential Challenges

Unfortunately, some aspects of ISPs may work against climate change mitigation even as they promote resilience objectives. Inorganic fertilizer use contributes to GHG emissions both through the soil chemical and biological processes and through the production of synthetic fertilizer. According to a recent estimate, 62% of global GHG emissions occur from agricultural production, and roughly 12 percent of agricultural GHG emissions occur from fertilizer (IPCC 2014). While currently not a major concern in Africa, it is worth noting that ISPs increase the quantities of fertilizer manufactured and used in the agricultural production process (holding all other factors constant) and therefore contribute to GHG emissions. The net impact of ISPs on GHG emissions will depend on the effectiveness with which ISPs can be used to promote adoption of CSA practices that raise soil organic carbon, sequester carbon, depress the rate of forest conversion to farmland, and offset the adverse effects of increased fertilizer use on GHG emissions. The empirical evidence on these issues is weak. More comprehensive research evidence is needed.

Moreover, there is the issue of opportunity costs. Nationwide ISPs tend to be expensive, and they can bid away scarce public funds that could otherwise be used to buffer communities from the effects of climate variability (e.g., irrigation, agricultural research and extension systems, weather insurance, etc.) or *ex post* coping responses (e.g., disaster relief programs). In Africa, where irrigation only accounts for 4% of arable land and where there is huge unmet potential for irrigation expansion, ISPs would seemingly compete against public investment in water control and other *ex-ante* risk management strategies. Future research is again needed to determine whether smart ISPs may be structured in ways that leverage private sector investments in CSA inputs and services and produce benefits that outweigh those generated from other proven types of public investments in agriculture.

6. CAN ISPS PROMOTE *EX POST* COPING POTENTIAL AT THE HOUSEHOLD LEVEL?

Governments frequently use ISPs to support food system and farm-level recovery from both detrimental climate and food price events. For example, ISPs can be scaled-up in the year following a severe weather event as part of drought-recovery strategies. In such cases, ISPs act as tools to support smallholder households' to acquire improved inputs and reengage in production following a severe contraction in farm income, and to potentially re-stock depleted resources that were expended during the crisis to smoothen consumption. ISPs can also be used to support replanting efforts in cases of poor germination or early season crop losses dues to late or false onset rains or pest outbreak. These are important household-level coping benefits.

To effectively achieve ex-post coping benefits for smallholder households, ISPs require significant budgetary flexibility, in order to responds to weather events, as well as managerial flexibility and capacity. In the case of intra-seasonal coping support to address early season failures, road infrastructure and farm access is also an important issue.

7. CAN ISPS PROMOTE SYSTEM-WIDE *EX POST* COPING POTENTIAL?

In their current form, ISPs tend to be costly and therefore compete directly for scarce public sector resources with other CSA risk coping and response strategies that might have more timely and direct impacts such as disaster risk management plans at various government scales, rapid repair of damaged infrastructure, emergency feeding, etc. However, modifications that enable ISP beneficiaries to gain access to weather insurance will help farmers to avoid the sort of asset and resource depletion that is common after a weather shock to smallholder systems. This, of course, is contingent on the effectiveness of these insurance programmes at delivering adequate and timely payments to affected farmers. In addition, ISPs may prove valuable, if well targeted, at enabling farmers to recover more quickly following weather events. In these ways, ISPs do offer some potential avenues for support food systems and economies to recover following an adverse weather shock.

8. CONCLUSIONS AND RECOMMENDATIONS

In almost all countries where they have been implemented, ISPs have clearly promoted national grain production, at least in the years they were implemented. ISPs have a more checkered track record in terms of their impact on farm-level productivity, input market performance, and farm management behaviors. Efforts to encourage policy makers to use *smart market* criteria for ISPs have made some progress in the region. However, low crop response to fertilizer, difficulties in targeting intended beneficiaries, and (in most cases) limited involvement of the private sector in the distribution of fertilizer have impeded the benefit-cost ratios of ISPs (Jayne et al. 2013; Jayne et al. 2015). It may be unrealistic at least in the near future to expect that political economy issues that have impeded longstanding efforts to make ISPs more effective can be easily overcome. However, given that ISPs are likely to continue and often account for a large share of public expenditures to agriculture, it may be worth the effort to encourage ISP reforms in ways that contribute to CSA objectives.

This study has considered potential avenues of ISP impact on CSA objectives in terms of a time dimension—*ex ante* risk management strategies vs. *ex post* coping strategies, and at different levels of intervention—household-level behavioral change vs. system-wide changes. Using this conceptual lens, we find that ISPs hold some potential to influence farmer behavior with respect to *ex ante* risk management strategies, such as promoting the adoption of sustainable land management techniques, small-scale water control investments, use of drought and heat resistant crop varieties and livestock breeds, and diversifying land and labour activities. The extent to which these can be achieved through ISPs is highly dependent on the existence of coordinated investments in both public extension services and research and development. Without effective bi-directional learning/extension services and monitoring systems, it is unlikely that ISPs on their own can serve to radically change farm-level management practices. Indeed, because ISPs compete directly with these alternative public investments, it is unlikely that a large-scale ISP can coexist with a highly functional extension and research system without much greater public budgets devoted to agriculture.

Where ISPs may provide greater opportunities to promote CSA objectives is through supporting *ex ante* risk management strategies at the system-wide level. If well designed, ISPs may serve valuable functions in terms of improve seed system performance for legume seeds and seed varieties that are adapted to current and future climate conditions. The current trend toward more market smart distribution modalities also offers significant opportunities to promote more accessible and competitive input markets for smallholders. Input market development is essential for enabling farmers to access the technologies they need to raise yields under current and future climate conditions. Finally, ISPs may also help to lower the cost of linking farmers to weather insurance systems.

However, trade-offs exist between market development objectives of new ISPs and some of these system-wide constraints to CSA, such as legume seed supply constraints. For ISPs to improve legume seed supplies they need to promote these through closed vouchers, yet this stands in contradiction to the sorts of flexible vouchers being widely promoted in the region. Managing these trade-offs is important for achieving greater system wide benefits through ISPs.

With regard to ISP's ability to improve the capacity of farm households to cope with shocks when they do occur, the most likely areas of influence are through their capacity to support post-disaster asset accumulation, and reengagement with productive agriculture, as well as helping farmers to replant in the case of early season crop loss due to late or false onset rains. Yet these outcomes, again, depend on effective public sector performance, particularly in terms of targeting the worse affected households.

In summary, ISPs may serve several catalytic functions at a system-level, including seed systems and input distribution system, which can support CSA objectives. However, achieving substantial

improvement in the performance of ISPs will require coordinated public and private investments in areas such as site specific adaptive research and extension, which are necessary to turn potential CSA practices into profitable and adoptable farm management strategies.

8.1. Options for Consideration

Based on this analysis we propose the following as potential focal areas for improving the climate smartness of ISPs in Africa:

- Support greater concentration of ISPs on climate smart seed varieties, including drought and heat tolerant varieties, and legumes: Many ISPs current focus primarily on staple cereal crops and fertilizers, with little attention paid to the characteristics of either. For ISPs to have a more system-wide effect on cropping systems and management practices, seed system constraints for other crops must be addressed. ISPs can serve a catalytic role in this respect.
- Develop detailed farm registries for ISP beneficiaries: Detailed registries, that include geo-spatial information, are necessary to delivery support services such as weather indexed insurance to farmers and to track adherence to targeting criteria.
- Explore the potential for using ISPs to overcome CSA farm management adoption constraints, bearing in mind that:
 - There is limited consensus on what practices are most effective for heterogeneous smallholder systems; and
 - Extension advice and monitoring capacity remains very thin in most of Africa.
- System support to improve timing of input distribution through ISPs: ISPs chronically deliver fertilizer late (Xu et al. 2009; Namonje-Kapembwa, Jayne, and Black 2014; Snapp and Fisher 2015). Late delivery reduces yields and crop response to fertilizer. This unfavorably affects the ratio of crop output to GHG emissions.
- Improve beneficiary targeting of ISPs: ISPs must more effectively target farmers who can use fertilizer profitably but are not already using it (or using it well below levels considered to be profit maximizing). This will reduce crowding out of commercial demand and contribute to increased fertilizer use. In addition, effective targeting of farmers and regions affected by weather-induced disaster can help ISPs to support *ex post* household and system-wide recovery efforts.
- Use extension systems to show farmers how the use of fertilizer from ISPs and/or commercially obtained fertilizer can become more profitable when complementary SI/CSA practices are adopted.

8.2. Unresolved Issues for Future Research

Key knowledge gaps include understanding why farmers are not adopting farm management practices such as conservation agriculture, which may have CSA benefits, or are subsequently dis-adopting them (which could then point to potential interventions to overcome these constraints); determining which practices are profitable for whom and under what conditions; understanding the interactions between CSA practices and ISP inputs (e.g., do selected CSA practices increase fertilizer use efficiency?); identifying cost-effective, enforceable, and scalable ways to implement a CSA precondition requirement for ISPs; and comparing the cost-effectiveness of such a requirement to that of other approaches to promote CSA.

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