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CLIMATE-SMART AGRICULTURE & RESOURCE TENURE IN SUB-SAHARAN AFRICA: A CONCEPTUAL FRAMEWORK

CLIMATE-SMART AGRICULTURE & RESOURCE TENURE IN SUB-SAHARAN AFRICA: A CONCEPTUAL FRAMEWORK

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Abstract

Though many studies document the positive impacts of various climate-smart agricultural (CSA) practices on crop yields, adoption of such practices remains limited in many areas in sub-Saharan Africa. A number of barriers to adoption have been identified, with many researchers noting the importance of property rights systems and tenure insecurity in particular. Nonetheless, few papers document the pathways by which current property rights and tenure security affect the adoption of CSA, or how altering either the bundle of property rights or the degree of tenure security over each piece of the bundle can lead to increased adoption of CSA. In this paper, we first discuss key characteristics of four CSA practices related to sustainable land management. We then lay out a conceptual framework for evaluating the pathways by which expanding property rights and strengthening tenure security affects incentives to adopt technologies broadly, and then apply the framework to each of the four CSA practices.

Keywords: Climate smart agriculture; sustainable land management; property rights; tenure security; sub-Saharan Africa

JEL codes: Q15, Q12, Q24

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1. INTRODUCTION

Responding to climate change, reducing rural poverty and achieving global food and nutrition security are three urgent and interlinked problems facing the global community today. Many people living in rural areas in developing countries are smallholder farmers reliant on rain fed agriculture, who are vulnerable to climate events. The long-term impacts of climate change are not yet fully understood, but it is expected that poor smallholder farmers will be among the most vulnerable groups due to this threat (Nelson et al., 2010; HLPE, 2012; Ngigi, 2009). The negative impacts of climate change on production, incomes and well-being can be avoided or ameliorated through adaptation, which includes changes in agricultural practices as well as broader measures such as improved weather and early warning systems and risk management approaches. Thus identifying changes in agricultural practices that result in effectively adapting to site specific effects of climate change, and their potential barriers to adoption is essential to addressing interlinked challenges of food security and climate change. Climate smart agriculture (CSA) is an approach that provides a conceptual basis for assessing the effectiveness of agricultural practice change to support food security under climate change. Particular attention is given to sustainable land management; a wide class of practice changes that have been shown to have productivity, stability and climate change mitigation effects.

For example, adoption of practices, such as agro-forestry species, minimum tillage and residue management, and soil and water conservation structures, can lead to climate change adaptation and mitigation benefits, as well increased and more stable yields, thereby increasing food security. Despite this potential, the adoption of such practices remains generally low, particularly in sub-Saharan Africa (SSA). One commonly cited barrier to increased adoption is the lack of robust property rights and an associated lack of land tenure security (FAO, 2013; Byamugisha, 2013; Giller et al., 2009). Relieving these barriers by increasing the bundle of property rights held by smallholder farmers as well as increasing tenure security over those rights can lead to greater investment in agricultural production, including higher adoption of CSA practices. Nonetheless, there is little empirical evidence of the pathways by which strengthened property rights directly affects the adoption rates. Such evidence is needed to design and implement effective property rights and tenure security interventions.

This brief describes hypothesized interactions between tenure security and adoption of changes in agricultural practices with high CSA potential, to help inform the design of CSA and tenure interventions, monitoring and evaluation plans, and impact assessment designs. It is structured as follows: Section 1 presents four categories of practices with high CSA potential, the potential to generate adaptation, mitigation and food security benefits, and costs and barriers to their adoption. Section 2 outlines five causal paths by which increased land tenure security/ property rights may lead to increased adoption of and investment in CSA. Section 3 lays out the “theory of change” by outlining the ways in which the four types of CSA practices from Section 1 may be impacted by the five causal paths identified in Section 2, identifying the path through which increased land tenure security/property rights can affect adoption of CSA. Section 4 concludes with a summary and recommendations for the design of impact evaluations, which will lead to a strengthened evidence base for future interventions dealing with both tenure and climate change.

2. ADAPTATION & MITIGATION BENEFITS OF CLIMATE-SMART AGRICULTURE

2.1 Climate-Smart Agriculture (CSA)

Climate-Smart Agriculture (CSA) is defined by the Food and Agriculture Organization of the UN (FAO) (2013) as a set of three core principles. These are:

1. Sustainably increasing agricultural productivity and income.
2. Adapting and building resilience to climate change. This includes increasing adaptive capacity in the short-term, where there is more uncertainty over climate extremes; and in the medium-long term, as permanent changes in climate patterns become more apparent (Cooper et al., 2013).
3. Where possible, reducing and/or removing GHG emissions, relative to business-as-usual practices.

Four broad categories of CSA practices have been identified for smallholder producers in SSA[1], both because they are realistic for smallholder producers in SSA to apply and have the potential to fulfill the three core principles of CSA enumerated above. With respect to adaptive capacity, below we address three primary types of climate change-related risk due to their relevance for smallholder farmers in arid and semi-arid regions of SSA (World Development Report, 2008). These are delayed onset of the rainy season (Shongwe et al., 2009; Dejene et al. 2011) increased soil temperature and higher evapotranspiration (Lal, 1988; Kirschbaum, 1995), and greater variability in weather patterns (Christensen et al., 2007).

At the outset, we note that nearly every practice discussed below will vary in effectiveness due to climate and soil conditions, as well as prevailing socio-economic conditions. Incentives to adopt and maintain such practices will also be affecting by the functioning of local institutions, such as input/output and credit markets, insurance and social safety net programs, information dissemination systems and agricultural extension, government and donor-funded projects, and, of course, property rights and resource tenure (FAO, 2013; McCarthy, Lipper, & Branca, 2011). Here we focus on property rights and land tenure, while acknowledging the wide range of factors that can affect the benefits and costs of CSA practices.

[1] We omit grassland and livestock management, which encompasses a set of CSA practices that may offer substantial mitigation potential in SSA. Evaluating the potential is even more complex than the options we discuss in this brief.

2.2 Conservation Agriculture (CA)

Conservation Agriculture (CA) has three primary principles pertaining to preparation of cropland (Liniger et al., 2011). The three core principles of CA are: 1) minimum soil disturbance; 2) permanent soil cover; and, 3) crop rotation (see http://www.fao.org/ag/ca). In practice, minimum soil disturbance includes a variety of different levels of tillage, but with the goal of minimizing soil disturbance. Crop rotation is the process of alternating the crops planted on land, ideally incorporating nitrogen-fixing plants in the crop cycle to increase soil fertility. Permanent soil cover involves planting cover crops, covering the soil with crop residue[2] from previous plantings, or using other types of mulch on the field post-harvest.

CA offers significant potential to help farmers in SSA to improve food security and adapt to climate change by increasing soil fertility, improving erosion control, increasing soil absorptive capacity, and easing drought stress due to improved water retention. Improved soil quality subsequently leads to higher average yields and reduced yield losses associated with extreme weather events (Blanco & Lal, 2008; Derpsch et al., 2010). Cover crops and the use of mulch can help manage soil temperatures, ameliorating negative impacts of increasing temperatures on crop yields (Hobbs et al., 2008). Tillage time is greatly reduced under CA practices, which allows farmers to plant in a more timely manner when rains do arrive, so that production levels are maintained even in shortened growing seasons due to delayed onset of rain (Hobbs et al., 2008).

Expected mitigation effects accrue due to reduced erosion which slows the loss of carbon sequestered in soil, as well as increased fertility leading to increased biomass and more sequestration potential (Smith, et al., 2008). Recent research indicates that net carbon flux under conventional tillage is relatively minimal, so little mitigation benefit is expected due to simply stopping tillage (Stockman et al., 2013). Thus, while CA may have high benefits in terms of adaptive capacity and food security in the medium- to longer-run, mitigation benefits may not be large.

Despite research showing the benefits of CA, particularly in drier regions subject to greater rainfall variability, adoption remains limited, likely due to the less-studied cash costs and other barriers to adoption (Arslan et al., 2012; Giller et al., 2009; Shetto & Owenya, 2007). Adoption may also entail high opportunity costs due to diverting residues from other traditional uses (e.g. animal fodder, cooking fuel) and increased labor for weeding (Lal, 2007). Managing CA practices often differs substantially from conventional farm management, and yield variability may actually increase as producers learn to manage the system (Graff-Zivin & Lipper, 2008). All of these potential costs need to be addressed for adoption to expand, and for farmers to realize food security and adaptation benefits.

[2] We also discuss cover crops and mulch under biological Soil and Water Conservation methods, although they are often practiced and discussed in conjunction with CA practices.

2.3 Agroforestry

The main categories of agroforestry practices are: use of trees and shrubs mainly as a soil fertility measure, including *Faidherbia albida* (Mokgolodi et al., 2011), *Sesbania sesbans, Gliricidia sepium* (Akinnifesi, et al., 2010; Ajayi et al., 2009; Phiri et al., 1999), as well as use of legume shrubs such as pidgeon peas. Trees and shrubs reduce erosion and improve water management through such practices as riparian forest buffers, windbreaks, alley cropping, forest farming, and silvopastoral practices (Blanco & Lal, 2008).

Certain species of trees or bushes offers the possibility to directly increase food security by allowing the household to harvest tree and bush products, thereby diversifying production and potential income sources (Blanco & Lal, 2008, p. 271; Byron & Arnold, 1999). Over time, food security is increased by improved soil quality leading to higher and more stable crop yields over time. Agroforestry practices increase absorptive capacity of soil (Blanco & Lal, 2008) and reduce evapotranspiration (McIntyre, Riha & Ong, 1996), which can ameliorate negative impacts of shortened growing seasons due to delayed onset of rain. The canopy cover from trees also has direct benefits in terms of reducing soil temperature for crops planted underneath (Young, 1989; Szott et al., 1991). Canopy cover also reduces runoff velocity and soil erosion due to heavy rainfall events (Blanco & Lal, 2008, p. 265).

Agroforestry mitigates GHG emissions by directly increasing carbon sequestration through increased biomass both above and below ground (Nair, 2012). However, for full mitigation potential to be reached, most agroforestry systems need to be established for long periods of time.

Costs and barriers to adoption include lack of available seed material, high mortality of seedlings during their first few years, and the often long timescales needed to reap the full benefits of various agro-forestry species (McCarthy et al., 2011).

2.4 Soil and Water Conservation (SWC)

A central focus of soil and water conservation (SWC) practice is to reduce or eliminate soil erosion and degradation. A related goal is to manage water quality through addressing rainfall runoff and factors influencing groundwater quality. Biological practices include improved fallows, cropping patterns, and manuring/mulching. Mechanical structures can be appropriate additions to land where biological methods are not sufficient to control erosion. Structures include terraces, *fanya juu*, ditches, ripraps, gabions, culverts, spillways, bunds, silt fences, and surface mats (Teshome et al., 2013; Tenge et al., 2005; Herweg & Ludi, 1999).

Adoption of biological SWC practices generates food security and adaptation benefits by reducing soil erosion, increasing fertility of plots, and improving water management. Improved fallows, manuring, and mulching are associated with improvements in soil water retention, which will help soils maximize benefit from precipitation they receive (Peterson & Westfall, 2004). These biological practices can also help reduce fluctuations in soil temperature (FAO, 2013). Riparian buffers and grass strip terraces can provide effective erosion control and contribute to increased soil fertility (Blanco & Lal, 2008; Bizoza & de Graaff, 2012; Kagabo et al., 2013). Mechanical conservation structures have shown potential to improve average yields, reduce yield losses in drought years, and reduce soil erosion (Deininger et al., 2011; Nkonya et al., 2011).

SWC practices have moderate mitigation potential by reducing losses of sequestered carbon caused by erosion, and may increase carbon sequestration through gains in biomass resulting from increased fertility. Limiting soil degradation may also limit burning and clearing of new plots (Vågen et al., 2005).

In terms of costs, applying mechanical measures is often labor-intensive, and may entail significant short-term opportunity costs (Teshome et al., 2013; Tenge et al., 2005). As noted above, biological practices often entail higher labor requirements, and lack of access to appropriate seeds is a common limitation.

2.5 Irrigation and Drainage

Irrigation systems are important methods to help adapt to climate change and improve food security in SSA (Ngigi, 2009; You et al., 2010). Appropriate drainage systems combined with collection systems can reduce erosion and help manage water access and regulate consumption of water in arid and semi-arid regions (Blanco & Lal, 2008).

Increased use of irrigation leads to food security and adaptation benefits by increasing average yields and decreasing variability of yields. Supplemental irrigation can also help maximize productivity in a shortened growing season due to delayed onset of rains (Ngigi et al., 2005). In addition, irrigation can help replace soil moisture loss due to increased evapotranspiration resulting from increased soil temperature (Poll et al., 2013). Availability of irrigation water will also help to adapt to less frequent but more severe rainfall patterns (Westra et al., 2013; Adger et al., 2007).

Irrigation leads to mitigation benefits primarily through increasing crop productivity and biomass. However, these gains may be partially or totally offset by emissions if pumps are used to bring groundwater to the surface, instead of relying on gravity-based systems (Smith et al., 2008).

In terms of costs, the storage capacity of existing irrigation systems may need to be expanded to manage more frequent extreme weather events (FAO, 2013). New irrigation projects, which require very high investment costs, may ultimately prove to be unsustainable in the long-run due to climate changes in precipitation and evapotranspiration rates, requiring detailed feasibility studies under a range of possible scenarios. Irrigation projects are also often undertaken collectively to help cover high up-front costs and take advantage of economies of scale, but then may be subject to failures of collective action in maintenance.

3. LAND TENURE AND CSA ADOPTION

There are a variety of reasons that farmers might choose not to adopt climate-smart agriculture practices, or adopt only a portion of a package of practices intended to work together, or try new technologies during a project but then revert to old practices once a project is completed. These reasons are complex, but may include lack of information, high up-front investment costs and maintenance costs in the face of cash constraints and thin/nonexistent credit markets, thin/nonexistent insurance markets, high variability in potential returns to investment, high opportunity costs of labor for certain practices, and risk associated with limited property rights and tenure insecurity (McCarthy et al., 2011).

Property rights for a piece of farmland might include use rights; management rights; and transfer rights, including by sale, lease or inheritance. Producers with a larger bundle of rights, and with greater security over each right within the bundle, are considered to have strong and secure rights. Both the breadth of rights, and security over each, matter for CSA adoption. For instance, a person with very secure use rights but limited management rights may not be able to keep others' animals from grazing their fields post-harvest. Alternatively, secure use rights combined with relatively insecure transfer rights will dampen incentives to invest in CSA practices that have delayed benefits.

For each of the CSA practices, we consider the impacts of increasing management and transfer rights but assume that, at least in the short-term, farmers have use rights. In addition, increasing security over each right is expected to lead to investment in agricultural production through three main causal paths (Brasselle et al., 2002; Besley, 1995).

- **Assurance.** Increased security means that farmers themselves will be able to reap benefits in the long-term. If farmers perceive that their claim to the land they use and manage is relatively secure in the long-term, they will be more confident that they will reap long-term benefits accruing from current investments. Here, we also consider ability to pass the land to heirs as providing greater assurance that investments made now will generate future benefits, though bequeaths might also be considered under transferability.

- **Collateralization**. Increased security means that farmers themselves can benefit from by accessing credit. Liquidity constraints are a well-known problem for small-scale producers, and may prohibit investments that require large up-front cash outlays as well as reduce expenditures on purchased inputs. Where credit markets function well – which unfortunately is typically not the case for most rural areas – producers with stronger rights and more secure tenure will more easily secure loans to finance investments and recurring input expenditures.

- **Transferability**. Increased security means that the farmer will be able to reap benefits from investments by transferring land to others. If increasing tenure security leads to greater ability to transfer land, causing the transactions costs of sale or lease to decline, farmers will be more willing to invest in long-term improvements that increase the value of the land because they will be better able to recoup investment costs by selling or leasing improved land.

In addition, given the potential to attract external funding for practices that mitigate emissions, or that provide environmental services more broadly, we also consider the potential impact of strengthened resource rights on attracting outside investment (e.g. payment for environmental services [PES] schemes) as a fourth path. Finally, and somewhat differently, we consider how strengthening tenure and property rights over communally held and managed resources, can affect CSA adoption.

- **Outside Investment**. Increased tenure security increases the likelihood that outside investors would be willing to contract with smallholder farmers for their greenhouse gas mitigation. PES schemes will be more willing to engage producers who hold unambiguous and enforceable use and management rights for their land – either as individuals or as groups. These contracts can provide a source of less variable income to producers who secure them. However, this benefit is also contingent on landscapes sequestering enough carbon to make investment worthwhile.

- **Community Tenure**. Increased tenure security over communal resources increases incentives to adopt CSA practices on these lands. Many CSA practices can improve the condition of common pastures and unallocated lands, and can also have positive spillover impacts on surrounding individually-held lands. Impacts from strengthened rights to communal resources will generally arise from greater assurance that community members will be able to reap benefits from these resources over the medium- to long-term, thereby fostering greater local public goods provision in terms of maintaining and investing in these resources.

4. PROPERTY RIGHTS AND TENURE REFORM IMPACTS ON CSA ADOPTION

This section outlines the ways in which projects, programs and policies aiming to strengthen property rights and increase tenure security are expected to impact uptake of CSA practices through expanding the bundle of rights held, and/or increasing tenure security through the five channels identified in Section Two. While the section builds on considerable empirical evidence, the section is meant to concisely summarize the causal pathways through which strengthening property rights and tenure security can lead to increased adoption of CSA practices. However, any specific project would need to consider locally-relevant information in determining which mechanism(s) would lead to greater CSA adoption.

4.1 Conservation Agriculture

- **Bundle of Rights**.
  - **Management**. Expanding management rights can be particularly important for the adoption of CA in many SSA countries. Farmers are usually free to manage their lands during cultivation, but may have far more restricted ability to manage lands post-harvest. Community norms, enforced by village leaders, regarding free-grazing livestock post-harvest on all lands means that it would be difficult to ensure that enough of your crop residue remains to cover the land, or to protect cover crops. Fencing would increase costs, and in some communities, fencing itself is not allowed. Burning fields post-harvest presents similar potential challenges in fully adopting CA.
  - **Transfer**. Customary rules regarding renting land vary across SSA. Even where it is prohibited by chiefs, the extent of enforcement also varies. Only a small fraction of land in SSA is formally titled, although sales still occur through informal channels. Expanding the right to rent or sell should increase incentives to adopt CA, though mainly through increasing security of transferability (described below) since benefits may be delayed.
- **Assurance**. On the one hand, full benefits may be delayed for 5 or more years, but on the other hand, up-front financing costs are typically relatively low. This implies that moderate benefits may be achieved by increasing assurance that farmers will realize returns to CA over the medium- to long-term.
- **Transferability**. Improved soil quality and fertility can lead to increased land value. But, it is often difficult for buyers or renters to directly observe increased soil quality associated with CA. Thus, there may be relatively modest benefits to having more secure rights to sell or lease rights.
- **Collateralization**. Secure property rights that expand access to short-term production credit can help finance increased variable costs of some inputs (e.g. herbicides, improved seeds for cover crops) that may increase with adoption of CA.
- **Outside Investment**. Strengthened property rights enable farmers to attract outside investors. However, though CA may offer some potential to sequester carbon through

increased biomass and decreased erosion, the evidence is weak. Thus, overall impacts may be relatively small through this mechanism.

- **Community Tenure**. CA is generally practiced on individually held cropland, so increasing community level land tenure security per se is unlikely to directly impact uptake unless this is also accompanied by increased tenure security for smallholders.

4.2 Agroforestry

- **Bundle of Rights**.
  - **Management**. Expanding management rights can also be important for agro-forestry adoption, though somewhat less important that CA. Fencing seedlings to avoid damage by animals in the first few years would be less costly than fencing an entire plot. Norms on burning, however, may increase costs of protecting seedlings. For agro-forestry species that also provide products that can be harvested, having the management right to exclude others from harvesting the products also increases incentives to invest.
  - **Transfer**. Greater ability to sell or rent increase incentives to invest, particularly since such investments are visible indicators that improve land quality. Additional benefits accrue through transferability, discussed below.
- **Assurance**. Since most agroforestry practices have a time lag between three and six years before full benefits will be realized, and some have even longer time lags, there is often a significant delay in benefits. Investment costs in terms of seedlings and in terms of ensuring survival can be relatively high. Delayed benefits with relatively high up-front financing costs means that assurance effects can be significant.
- **Transferability**. Increasing security over the rights to transfer land increase incentives to invest in agroforestry since trees and bushes visibly enhance the value of land, even before full benefits are realized. Secure transfer rights therefore reduce both the risks associated with high up-front costs of establishment and with not being able to realize benefits in the future.
- **Collateralization**. Greater credit access through strong and secure property rights may increase the speed of uptake mainly due to increased ability to purchase appropriate seedlings and other associated inputs.
- **Outside Investment**. The capacity of agroforestry systems to sequester carbon, and the relative ease of observing/monitoring agroforestry adoption make this an attractive option for outside investment. As noted above for conservation agriculture, strengthened tenure security increases the ability of farmers to attract such investment.
- **Community Tenure**. Increasing communities' rights and security over communal land can increase incentives to invest in agro-forestry on communal lands, particularly in areas that would provide public goods spillovers for both communal and individually held-land, e.g. communal lands located on sloped land above cultivated fields. Outside investment may be also be attracted to agro-forestry project undertaken on communal lands, since larger-scale projects tend to have proportionally lower transaction and enforcement costs.

4.3 Soil and Water Conservation

- **Bundle of Rights**.
  - **Management**. Given that most farmers already enjoy the management rights to invest in soil and water conservation measures, expanding such rights may have relatively modest impacts on incentives to invest in SWC.
  - **Transfer**. As with agro-forestry, SWC investments are visible indicators of land improvements, and should increase land values relatively quickly, rising in time until the full benefits of such investments are realized. As with all CSA practices, rights to transfer are a requisite to benefitting from increased transferability.
- **Assurance**. Assurance effects are likely to increase investment in mechanical conservation structures due to the high upfront costs and time lag for returns. Biological SWC measures are generally fairly low cost to implement, so assurance effects should be more muted. Fallowing is an important exception to other biological SWC measures since fallow land is often a greater risk of re-allocation by the village headman/chief. Greater tenure security thus makes fallowing more attractive.
- **Transferability**. Biological and mechanical SWC techniques increase fertility of land and reduce erosion, which will increase land value. Greater ease in selling land may lead to greater investment in these practices due to this effect.
- **Collateralization**. Increased access to credit due to collateralization effects may increase significant up-front investments in mechanical SWC.
- **Outside Investment**. The potential carbon sequestration benefits accruing to biological SWC practices offer limited potential to attract outside investment. Reduced losses of carbon through erosion due to mechanical SWC are not yet clearly identified, which is likely to limit outside interest in investment.
- **Community Tenure**. As with agro-forestry, increasing communal tenure security may be important to motivate investment in larger scale conservation structures that generate large public benefits, such as strategically placed include terraces, *fanya juu*, ditches, culverts, check dams and spillways, bunds, etc.

4.4 Irrigation and Drainage

- **Bundle of Rights**.
  - **Management**. As with SWC, farmers generally already enjoy the right to use drainage and water collection systems, for irrigation or any other purpose, implying a limited role for expanding management rights. On the other hand, for irrigation using groundwater or diverted surface water, farmers would require the right to use and manage these water sources. Many farmers have access to plots in larger-scale irrigation schemes, however, where a good deal of management rights are held at the scheme-level.
  - **Transfer**. Greater ability to sell or rent increase incentives to invest in individual-level irrigation, since again the investment is visible, and full benefits

accrue nearly immediately. Additional benefits accrue through transferability, discussed below.

- **Assurance.** For many irrigation investments, investments costs can be recovered in a relatively short time period, meaning that assurance effects may be moderate. Of course, the longer it takes to recoup investment costs, the more important the assurance effect becomes.
- **Transferability.** Greater security in the ability to lease or sell land increase incentives to invest in irrigation or drainage systems, since such investments are readily observable and should immediately raise sale and lease value of the land. On the other hand, where investment costs can be recovered more quickly, transferability is relatively less important vis-à-vis those CSA practices with high up-front costs but delayed benefits.
- **Collateralization.** Collateralization effects may make irrigation investments more affordable, particularly if farmers need to pay equipment, e.g. groundwater pumps or surface water diversion equipment. Thus, if available, collateralization may have a significant effect on initial investment.
- **Outside Investment.** Irrigation does present some potential to increase carbon sequestration due to increased biomass, at least for gravity-based systems. As such, it may be an attractive area for outside investment, and strong and secure property rights can help attract that investment.
- **Community.** Inducing collective action to undertake investments in irrigation projects on communal lands may be particularly important for irrigation systems that have "increasing returns to scale" over some range (e.g. gravity-based small dams systems), and thus would be more costly if adopted by an individual. Strengthening property rights and tenure security over these lands should increase incentives to collectively invest in communal level irrigation schemes. However, management costs of such schemes can be very high, and must often rely on voluntary collective action in maintenance.

5. SUMMARY AND RECOMMENDATIONS

The link between increased land tenure security and increased investment in agriculture is fairly well established in the literature, although it is also clear that increasing property rights and tenure security alone are often not sufficient to stimulate investment (Deininger & Feder, 2009; Maddison, 2006). The potential benefits of various CSA practices for producer livelihoods and climate change adaptation and mitigation are also widely discussed in the literature (McCarthy, et al. 2011; Branca, et al. 2012; Kaczan, et al. 2013; Smith, et al. 2008). However, there remains a dearth of empirical evidence on the exact mechanisms by which strengthened property rights and tenure security can spur adoption of CSA practices. In fact, despite the many benefits associated with CSA practices, uptake remains low in SSA (Asfaw, et al. 2014; Arslan, et al. 2013 Gowing & Palmer, 2008; Lal, 2007; Derpsch et al., 2010). Land tenure security is a restricting factor that comes up repeatedly to help explain low investment in CSA (FAO, 2013) and in agriculture more generally (Byamugisha, 2013); however, studies are generally quite vague about exactly exactly property rights and tenure security affect adoption rates. This brief has described a conceptual framework for designing, implementing, monitoring and evaluating projects which seek to increase land tenure security and adoption of CSA practices through a detailed examination of causal pathways that inform a "theory of change.

Figure 1 illustrates the types of CSA and potential property rights/tenure effects according to the expected strength of the interaction. So, cells containing "Strong" are those where interaction effects are expected to be relatively strong. This provides insight to policy-makers concerned with increasing the rate of adoption of CSA practices, indicating where land tenure interventions are likely to have an effect on adoption rates and the type of intervention with most potential.

Figure 1: Matrix of CSA Practices and Property Rights/Tenure Security Impacts

	Conservation Agriculture	Agroforestry	SWC: Biological	SWC: Mechanical	Irrigation and Drainage
Assurance	Moderate/ Weak	Strong	Moderate/ Weak	Strong/ Moderate	Moderate/ Weak
Realizability	Moderate	Strong/ Moderate	Moderate	Strong/ Moderate	Strong/ Moderate
Collateralization	Weak	Moderate/ Weak	Weak	Strong/ Moderate	Strong/ Moderate
Outside Investment	Weak	Strong/ Moderate	Weak	Moderate/ Weak	Moderate
Community	Negligible	Strong/ Moderate	Negligible	Moderate	Strong/ Moderate

Of course, the table is based on evidence from a broad review of the empirical literature, and so would need to be updated for specific circumstances; e.g. to verify the range of benefits obtainable under site specific circumstances from adoption, as well as site specific barriers to adoption. The table provides a good starting point for conducting more detailed assessments to identify preferred options for CSA practice change and policy interventions in land tenure arena to support them. In this sense it is an important step forward in building the evidence base needed to support effective land tenure interventions intended to increase food security under climate change.

A final important issue to consider here is the implications of this analysis for designing effective impact assessments of tenure interventions. All of the CSA practices presented here can provide significant benefits to producers who adopt them, provided the practices selected are appropriate for the climate and other socio-economic conditions that the farmer faces. However, some of the practices will be more sensitive to changes in the property right bundle/tenure security than others. Practices that are sensitive to assurance effects are of particular interest since they should provide impact evaluation results that are simpler to interpret, particularly over the short-medium term. The impacts of transferability, collateralization, and outside investment are more strongly related to supra-household factors – often unobservable – that affect the functioning of rural land markets, credit availability, and the enabling environment for attracting outside investment. The latter three channels can be important, and observable, but would require a longer timeframe and expanded data collection.

The empirical evidence suggests that assurance effects should be relatively high, and thus more readily observable, for agroforestry, mechanical conservation structures, and fallowing. We note that agroforestry and conservation structures can also both be practiced on individual plots and communal land. Strengthening communal property rights and tenure security may therefore be significant in areas where communal pastures, forests, and unallocated fallow land are prevalent. A well-structured and implemented impact evaluation is particularly important in understanding the synergies between strengthened tenure and resource rights and adoption of CSA practices. While there is evidence of the links between strengthened tenure and resource rights and increased investment on-farm, there is far less rigorous evidence on those links for CSA specific technologies. Given the importance of climate change to vulnerable agricultural producers in SSA, empirical evidence is needed to guide interventions that lead to greater food security and adaptive capacity, while at the same time following a low-emissions strategy.

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Economics and Policy Innovations for Climate-Smart Agriculture (EPIC)
EPIC is a programme hosted by the Agricultural Development Economics Division (ESA) of the Food and Agriculture Organization of the United Nations (FAO). It supports countries in their transition to Climate-Smart Agriculture through sound socio-economic research and policy analysis on the interactions between agriculture, climate change and food security.

This paper has not been peer reviewed and has been produced to stimulate exchange of ideas and critical debate. It synthetizes EPIC's ongoing research on the synergies and tradeoffs among adaptation, mitigation and food security and the initial findings on the impacts, effects, costs and benefits as well as incentives and barriers to the adoption of climate-smart agricultural practices.

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