SIMLESA – Gaps and Opportunities with CSA relevance

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An assessment of CSE/2013/008 'Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa' (SIMLESA) in relation to the principles of Climate Smart Agriculture (CSA) and identify research priorities and gaps.

Brian Keating, March 2017

Summary

In this report, we explore how the SIMLESA program might evolve in future in a manner that is more relevant to the principles of Climate Smart Agriculture (CSA). We approach this via the three core pillars of CSA; agricultural productivity/food security, climate change adaptation/resilience, greenhouse gas mitigation.

Opportunities for SIMLESA to strengthen its relevance to CSA are found for all three pillars. Conclusions include;

- The agricultural productivity “pillar” of CSA has been the dominant focus of SIMLESA and provides a strong foundation for evolving SIMLESA through a CSA lens.
- The SIMLESA sustainable intensification pathway requires as a first step some fertiliser inputs, yet the economics of fertiliser use under smallholder on-farm conditions and maize market prices are uncertain. A formal analysis of the economics of small-holder fertiliser use in SIMLESA regions would be very instructive.
- Diversification of the productivity focus beyond maize to include opportunities for smallholder engagement in markets should be considered in a context-sensitive way as a means of building market connections and generating cash resources.
- Looking forward, if SIMLESA was to strengthen its CSA credentials, it should continue to move beyond agricultural productivity *per se* and strengthen its livelihoods and food/nutritional security foci.
- SIMLESA’s focus on risk management in the face of multiple sources of risk, but including climate/weather risk is appropriate and an important contribution to the climate adaptation pillar of CSA.
    - The climate adaptation dimension could be strengthened by better analysis of observed weather patterns over the last 25-50 years in SIMLESA regions and a more in-depth analysis of risks at the household level associated with SIMLESA’s sustainable intensification package of technologies and practices.
    - This climate adaptation analysis should examine the extent to which any observed climate change and/or an ensemble of climate projections for the regions materially changes the viability of the sustainable intensification pathways.
- Sustainable intensification requires attention to N fertiliser inputs, fertilisers other than N as appropriate and legume fixed N as part of a broader integrated soil fertility management strategy. These inputs can increase greenhouse gas emissions but their impact on productivity will be many times greater and the overall impact of eco-efficient soil fertility management will be to lower the greenhouse gas <u>intensity</u> (emissions per unit food produced) of the food system.
- A CSA focused evolution of SIMLESA could place greater emphasis on livestock productivity, markets for livestock products, livestock’s role in risk management and resilience in the face of weather variability and opportunities for greenhouse gas mitigation.
- A greater focus on soil fertility generally and the C/N dynamics of conservation agriculture interventions would be a necessary element of any efforts to evolve SIMLESA via the CSA lens.

- Greenhouse gas mitigation and carbon sequestration have not been foci of SIMLESA's sustainable intensification journey to date – but there are strong and generally positive opportunities to pursue mitigation outcomes from SIMLESA's productivity enhancing practices and technologies. A focus on mitigation in isolation of food security and poverty reduction goals would be inappropriate but there are opportunities to pay greater attention to the mitigation co-benefits of sustainable intensification pathways going forward. Some specific opportunities include:
    - Greater attention to livestock productivity issues
    - Attention to alternative livestock breeds with lower greenhouse emissions intensity (eg chickens)
    - Greater attention to the soil C/N dynamics of the conservation agriculture systems
    - Consideration of the net impacts of mechanization on household energy/greenhouse gas balances
    - More attention to agro-forestry and household bio-energy opportunities

Background

The SIMLESA Project (Sustainable Intensification of Maize-Legume Cropping Systems for Food Security) has been investigating opportunities and constraints to sustainable intensification of small-holder farming systems in eastern and southern Africa. Key focus countries have been Ethiopia, Kenya, Tanzania, Malawi and Mozambique. CIMMYT have been the coordinating implementing agency working with national R, D and E partners. ACIAR is the primary funding agency. The Project commenced in 2009 and the second phase is due for completion by mid-2018.

This report forms part of a small assessment project commissioned by ACIAR to:

1. To assess the alignment of the current SIMLESA results to the principles of "Climate Smart Agriculture" (CSA).
2. To identify priority research questions/gaps which might be considered in follow-on research.

This report builds on the meta-analysis of SIMLESA publications, the CSA review and the review of SIMLESA outputs against CSA frameworks **(See C2016/212a, b and c)**. It also emerges following a workshop with SIMLESA team members and a field visit to SIMLESA activities in Chimoio region of Mozambique both of which stimulated lively discussions on future evolution of SIMLESA activity.

Gaps and opportunities from a CSA perspective

Agricultural productivity and food security

SIMLESA has had a very strong focus on lifting agricultural productivity through a mix of context-sensitive technologies and practices that are intended to contribute to sustainable intensification. In the main these come together under the banner of "conservation agriculture", as defined by SIMLESA to include;

- Reduced tillage
- Residue retention or mulching
- Herbicide control of weeds
- Inclusion of grain or forage legumes in the maize system either in rotation, intercrops, double crops or relay crops.

Use of the most relevant improved germplasm and fertiliser inputs that accord with local recommendations are also an integral part of the overall intensification package. These latter two interventions are assumed as a necessary first step along the road to lift agricultural productivity and they have not generally featured as an experimental variable in SIMLESA trials and demonstrations. This issue will be re-visited in a later section that will focus on constraints to adoption of the SIMLESA sustainable intensification package.

Conclusion: The agricultural productivity "pillar" of CSA has been the dominant focus of SIMLESA and provides a strong foundation for evolving SIMLESA through a CSA lens.

The productivity of maize as the primary staple in the systems of interest has dominated SIMLESA's attention, followed by a significant level of attention to the productivity of grain legumes. In the absence of cash flows into the farming system from the sale of "cash crops or livestock products", it is hard to see how the initial investments in inputs (improved seeds, fertilisers, herbicides) are going to be achieved. The grain legumes do provide some cash sales opportunities and there is some evidence these opportunities are growing with increasing market connections and demand. Markets are likely to be more regulated for staple cereals such as maize and economic incentives for production and sale of surpluses not as strong. Some "back of the envelope" calculations suggest the sale of an additional tonne of maize grain would be needed to cover the costs of a 50kg bag of fertiliser in Mozambique and that on-farm fertilise use efficiencies are unlikely to achieve such responses. [Note: a formal analysis of the economics of fertiliser use on maize in SIMLESA regions would be very instructive]. Diversifying production/productivity opportunities beyond maize (and legumes) may be an essential step to create the resources for spill-over investments back into the maize system.

Conclusion: The SIMLESA sustainable intensification pathway requires as a first step some fertiliser inputs, yet the economics of fertiliser use under smallholder on-farm conditions and maize market prices are uncertain. A formal analysis of the economics of small-holder fertiliser use in SIMLESA regions would be very instructive.

Conclusion: Diversification of the productivity focus beyond maize to include opportunities for smallholder engagement in markets should be considered in a context-sensitive way as a means of building market connections and generating cash resources.

The interest in agricultural productivity is a means to the broader objective of improving livelihoods and food and nutritional security of smallholders and rural communities. There has been less focus on the longer term desires for improvements in livelihoods and food/nutritional security, at least from the perspective of the SIMLESA publications meta-analysis. The SIMLESA baseline surveys capture relevant data and typologies. Recent survey work with "case study farms" has apparently looked more deeply into food security issues and there has been SIMLESA involvement in some publications which have explored bigger questions of determinant of food security.

Conclusion: Looking forward, if SIMLESA was to strengthen its CSA credentials, it should continue to move beyond agricultural productivity *per se* and strengthen its livelihoods and food/nutritional security foci.

Climate Adaptation and Resilience

SIMLESA activities have not specifically focused on climate change impacts and adaptation studies. Traditionally such studies have looked at differences between current and projected future climate (say out to 2030 or 2050) and explored how genotypes or management practices might need to change to suit climate change projections.

The practical reality is that farmers rarely decide to "adapt" to some projection of future climate. To do so would generally be very unwise from both the perspectives of uncertainties in future climate projections for specific regions and a mis-match in time scales that means current management has to deal with the realities of current weather – not a long term future projection of climate. Farmers deal with the weather variability they experience now, interpret that in terms of past weather variation they have experienced and gradually evolve their practices to better align with the weather variability they are experience going forward. Breeding programs for crop germplasm also "auto-adapt" to evolving weather patterns although there may be value (as yet not well demonstrated) in including specific climate adaptation traits in the breeding objectives.

At some point in the future, both farmers and researchers will be able to look back and see that the climate has indeed materially changed and that practices and technologies have adapted to varying degrees of success. Under these circumstances, a productive approach to climate change adaptation for small-holder farmers is to look at how well the weather risks are being dealt with now and to keep a watch on the likelihood of particular weather risks intensifying or changing into the future

SIMLESA activities have not focused on climate change adaptation, with a few exceptions, including a SIMLESA-related paper by Tesfaye et al 2015 (*Maize systems under climate change in sub-Saharan Africa.*). Despite this, risk management has been a high level objective of SIMLESA, and the high level objectives were set at a 30% increase in maize yields and a 30% reduction in downside yield risks. The appropriate indicators for risk were discussed during the CSA Workshop in Harare – is standard deviation the appropriate measure or some more targeted threshold such as chances of household food supply falling below some threshold?

The extent to which observed weather patterns to date can be considered to be evidence of "climate change" in SIMLESA countries and regions was also discussed at the CSA Workshop and there would appear to be an opportunity for a better understanding of what the data are indicating.

Conclusion: SIMLESA's focus on risk management in the face of multiple sources of risk, but including climate/weather risk is appropriate and an important contribution to the climate adaptation pillar of CSA.

- **This dimension could be strengthened by better analysis of observed weather patterns over the last 25-50 years in SIMLESA regions and a more in-depth analysis of risks at the household level associated with SIMLESA's sustainable intensification package of technologies and practices.**

- **This latter analysis should examine the extent to which any observed climate change and/or an ensemble of climate projections for the regions materially changes the viability of the sustainable intensification pathways.**

Greenhouse gas mitigation and carbon sequestration

The issue of the appropriateness of a greenhouse gas mitigation objective for smallholder farmers in SSA generated considerable discussion and debate during the CSA Workshop. Greenhouse gas mitigation has not explicitly been an objective of SIMLESA activities to date and many workshop participants were doubtful about the appropriateness of this third pillar of CSA to SIMLESA going forward.

The larger scale context of this debate is that many developing country governments view the mitigation burden should fall on the developed countries who have been the source of the majority of greenhouse gas emissions to date. They see a mitigation objective to be at odds with other drives of economic development ad food security. Instead of getting caught up in these bigger negotiating positions of national governments in global climate action agendas, we focused our discussions more towards what mitigation means in terms of the sustainable intensification pathways of farm households. Our starting point here was that reducing poverty and ensuring food security of smallholder farmers was going to have primacy. Where greenhouse gas mitigation (including carbon sequestration) aligned with these primary objectives then opportunities for "win-wins" might be pursued.

A participant in the workshop expressed these linkages as follows;

"Productivity/Food security and Adaptation are preconditions for mitigation. Increasing productivity, stemming resource degradation and strengthening adaptive capacity are important pre-conditions for mitigation. So too strong a dichotomy between the three elements may be unhelpful in framing our thinking and development approaches." …. Paswel Marenya, CIMMYT Economist

The global imperatives for greenhouse gas mitigation and carbon sequestration are strong and likely to get stronger and the opportunities for agriculture and the land/forest sector are going to get greater attention. We did not focus on how emerging global carbon markets might interface with smallholder agriculture sector in SSA – however pursuit of "win-wins" could be fostered by emerging global imperatives to dramatically ramp up mitigation effort over the next 30-50 years.

So where are the mitigation-productivity "win-wins" of relevance to SIMLESA?

The "sparing" argument arising from sustainable intensification

Expansion of agricultural cultivation onto grasslands, woodlands and/or forested lands represents generates greenhouse emissions from biomass and soils. Improvements in agricultural productivity have a potential "sparing" effect on land/vegetation -based greenhouse gas emissions. Burney (2010) has estimated the improvements in agricultural productivity globally from 1961 to 2005 has "spared" the atmosphere of 161 $GtCO_2$-e emissions that otherwise would have arisen from expanding less productive agricultural cultivation onto grasslands or forest lands. This benefit is estimated even after allowance for the greenhouse gas emissions associated with agricultural inputs such as fertilisers and/or cultivation. In other words, lifting agricultural productivity through "sustainable intensification" leads to a globally lower net greenhouse gas footprint for agriculture than the alternative of expanding the land area of a lower productivity agriculture.

The nitrogen fertiliser and legume N issues

Greenhouse emissions associated with fossil fuels used in nitrogen fertiliser manufacture are not directly attributed to agricultural production, but from a full life cycle perspective they are a significant indirect source. Some fraction of the nitrogen supplied as fertiliser will be lost as nitrous oxide (N_2O) – a powerful greenhouse gas. Typically this fraction would be estimated as less than 1% of the N in the fertiliser but under conditions conducive to denitrification where high levels of soil nitrate and soluble carbon were present, N_2O loss could be as high as 5%. So is the use of nitrogen fertilisers "climate smart"? Certainly overuse and wastage of nitrogen fertilisers in definitely not climate smart – nor is it desirable for soil and environmental health. Efficient use of nitrogen (or other fertilisers as the case may be) is essential for agricultural productivity and global food security would be placed in doubt without nitrogen fertilisers. It is likely that agricultural productivity would be at least halved without N fertilisers – perhaps reduced to one quarter of current levels globally. It is unlikely that such a shortfall could be met by expansion of the land footprint of agriculture or sourcing of alternative sources of N such as from animal manures or legumes – but moves in either direction are likely to increase greenhouse gas emissions. So we conclude that careful use of nitrogen and other fertilisers is "climate smart" in situations where it is "eco-efficient" (see Keating et al 2010). The best outcomes for the climate and the wider environment will result from careful integration of fertilisers with other sources of nutrition including manures and legumes. In recent times this has come to be referred to as Integrated Soil Fertility Management (Vanlauwe et al 2015).

Inclusion of legumes in rotations and intercropping systems makes a positive contribution to soil fertility status – but productive legume crops will often require some phosphorous fertiliser inputs. From a CSA perspective, the N fixed from legumes is a positive as it avoids fossil fuel use in N fertiliser manufacture. Legume fixed N is still exposed to denitrification losses and it is uncertain whether the nitrous oxide losses from systems with significant legume components are higher, the same or lower that N fertilised systems.

Conclusion: Sustainable intensification requires attention to N fertiliser inputs, fertilisers other than N as appropriate and legume fixed N as part of a broader integrated soil fertility management strategy. These inputs can increase greenhouse gas emissions but their impact on productivity will be many times greater and the overall impact of eco-efficient soil fertility management will be to lower the greenhouse gas intensity of the food system.

The livestock productivity and greenhouse intensity issue

Methane emissions from enteric fermentation in ruminants is the dominant source of greenhouse gas in small-holder systems in SSA currently. Low productivity herds fed on poor quality feeds are very inefficient from a greenhouse gas perspective. Improved feeding regimes in beef or dairy animals could raise productivity and significantly reduce the greenhouse gas intensity of the livestock component (i.e., kg CO_2-e GHG per tonne of livestock product). In addition to lifting productivity in beef or dairy animals, shifts to other species such as goats or chickens could reduce the greenhouse gas intensity of livestock production (Figure 1).

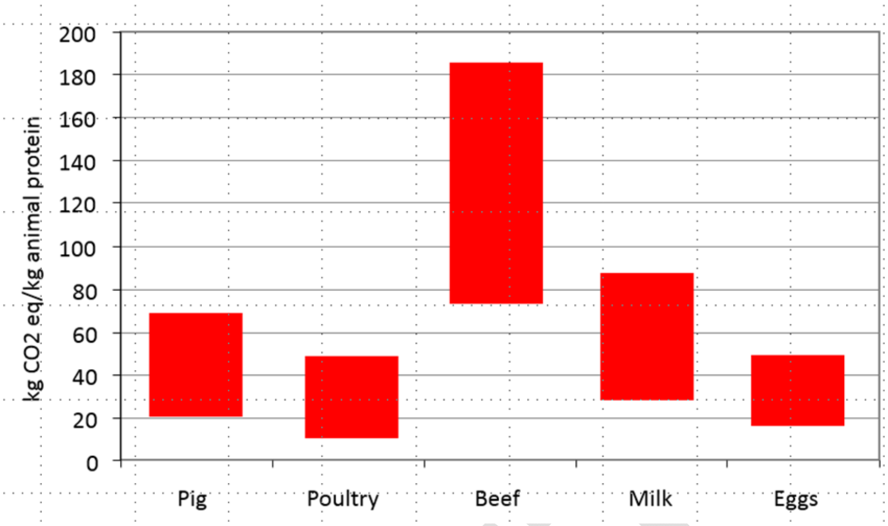

Figure 1. Greenhouse gas intensity of a range of livestock products. From de Vries de Boer (2009).

Any such shifts would need to align with market opportunities. As a broad generalisation, the livestock component of the farming systems studied in SIMLESA has not received the same attention as the cropping component.

Conclusion: A CSA focused evolution of SIMLESA could place greater emphasis on livestock productivity, markets for livestock products, livestock's role in risk management and resilience in the face of weather variability and opportunities for greenhouse gas mitigation.

The soil carbon issue

Residue retention and reduced tillage (key aspects of Conservation Agriculture, CA) has been a major focus for SIMLESA to date. These practices are likely to be at worst neutral but at best positive in terms of soil carbon sequestration. In the recent review of CA by Thierfelder et al (2017), the evidence for soil carbon accumulation after extended periods of conservation agriculture was equivocal. These authors state:

"The available data summarizing the effects of CA on soil organic C (SOC) and reductions in greenhouse gases, are often contradictory and depend a great deal on the agro-ecological environment and the available biomass for surface residue retention. There is an urgent need for more research to better quantify the mitigation effects, as the current data are scanty.

Soil organic matter cannot be built up without microbial access to a full range of nutrients, in particular N, P, K and S. Herein lies one possible explanation for the observed variability in soil carbon impacts following years of CA – without access to these nutrients the efficiencies of C transfer into stable organic matter pools will be restricted. A review of longer-term soil carbon changes under zero-till / residue retention grain farming systems in Australia (Sandeman et al 2010) suggests modest increases in the order of 0.2 to 0.3 tC/ha/yr were likely – noting however that fertiliser inputs are a common feature of these systems in addition to the residue returns.

While there are relatively few SIMLESA publications addressing soil fertility dimensions of CA, there are long-term on-station trails gathering relevant data on C&N dynamics of CA. The CSA "credentials" of SIMLESA's conservation agriculture/sustainable intensification package would be significantly enhanced by data that shows how soil carbon can be significantly and reliably sequestered.

Conclusion: A greater focus on soil fertility generally and the C/N dynamics of conservation agriculture interventions would be a necessary element of any efforts to evolve SIMLESA via the CSA lens.

Net impacts of mechanisation

Interest in small-scale mechanisation has been growing in SIMLESA and related projects. This is a natural evolution of interest in residue management, reduced tillage and herbicide-based weed control. Looking ahead, it may be valuable to consider what the CSA credentials of greater mechanisation look like? Some greenhouse emissions from fossil fuel use may be offset by significantly enhanced productivity – in particular arising from improved timeliness or operations and effectiveness of weed control. An analysis of how mechanisation could influence the net greenhouse gas balance of smallholder systems progressing down a sustainable intensification pathway would be a valuable contribution.

Agro-forestry prospects

Agro-forestry does not appear to have been a strong focus in the SIMLESA projects – but it remains relevant as a source of residues for the CA practices being pursued in SIMLESA. N-fixing leguminous shrubs and trees grown in parts of the farming landscape unsuited to cultivation could enhance the feasibility of CA systems and contribute positively to the CSA performance of such systems going forward.

Food system issues – value chains and off-farm issues

SIMLESA has placed most emphasis on on-farm production issues but engagement with markets and value chains is emerging from the partnering activities looking to scale-up impacts. The greenhouse mitigation opportunities along food value chains may be worth some attention – particularly in situations where the CSA credentials of the food system has some market value or linkages.

Household energy systems

The household energy system of SIMLESA target agro-ecologies is still largely powered by wood collection and/or charcoal production. Looking forward, there may be value in taking closer interest in household energy systems – are there opportunities for improved fuelwood supplies in these farming landscapes? Are there opportunities for bio-energy? Can the greenhouse gas balance of the farm household be improved in any way?

Overarching Conclusion: Greenhouse gas mitigation and carbon sequestration have not been foci of SIMLESA's sustainable intensification journey to date – but there are strong and generally positive opportunities to pursue mitigation outcomes from SIMLESA's productivity enhancing practices and technologies. A focus on mitigation in isolation of food security and poverty reduction goals would be inappropriate but there are opportunities to pay greater attention to the mitigation co-benefits of sustainable intensification pathways going forward. Some specific opportunities include:

- **Greater attention to livestock productivity issues**
- **Attention to alternative livestock breeds with lower greenhouse emissions intensity (eg chickens)**
- **Greater attention to the soil C/N dynamics of the conservation agriculture systems**
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- **More attention to agro-forestry and household bio-energy opportunities**

Beyond CSA thinking – the overall adoption challenge

Pursuit of sustainable intensification through a CSA lens is feasible and desirable but meaningless if it does not have impact in practice in the farm households and food systems of SSA.

Paswel Marenya (CIMMYT Economist) expressed the issues in this way;

"CSA is an integral part of sustainable agricultural intensification (SAI): with the issue of climate change settled, SAI has to be climate smart really. Anything that's not climate smart cannot be SAI. So in concept and practice we have to have climate smart and resilience as part of SAI. We cannot talk of SAI then talk of CSA separately…if it's not imparting resilience to change including climate changes it's not sustainable".

SIMLESA has identified and demonstrated attractive pathways to sustainably lift productivity. These pathways however all require a combination of various inputs and practice change, including;

- Foundational inputs of improved crop genotypes (cereals and legumes) requiring farmers to purchase improved seeds
- Foundational inputs of purchase fertilizer inputs (nitrogen and other nutrients as dictated by soil properties) and sometimes supplemented by manures and other leguminous residues. Nitrogen and phosphorus fertilizer are likely to be the biggest single financial hurdle for the entire sustainable intensification package.
- Purchase and application of herbicide products and in some circumstances pest control products.
- Mulch production or procurement and altered tillage regimes – these are not necessarily major cash commitments and can involve significant labour savings.

The financial obstacles to these sustainable intensification investments cannot be underestimated and more so for staple cereals given typical distortions in market signals as discussed above. The place for diversification and use of cash crops with stronger market opportunities as a vehicle for spill-overs into staple crop inputs is worthy of close attention.

Without policy and institutional settings that "enable" this sustainable intensification journey adoption beyond the initial demonstration engagements with farmers will not be sustained. These settings include issues to do with markets and value chains, public policy settings, private sector activity as well as community and civil society dimensions (Figure 2).

While these challenges are generally recognised by the SIMLESA team, less attention has to date been given to enabling policies and institutions for sustainable intensification (and hence also for CSA). Recent engagement with actions along supply chains and markets via the competitive grants scheme (such as with AGRIMERC) in Mozambique is a step in the right direction – but these activities could be ramped up and form a core foundation of future work. Engagement with “scaling-up” partners needs to go beyond demonstrations and experiential learning. SIMLESA is well placed to develop a solid scientific base for understanding the necessary ingredients of successful scale-out of agricultural technologies and practices. Developing generalised “global public goods” on this scale-out challenge is not easy but with careful design and the right teams of social, economic and bio-physical scientists, SIMLESA could make a useful contribution going forward. There is considerable experience in policy and institutional engagement in the CSA community and one advantage of SIMLESA including a CSA “lens” in future would be to strengthen these policy and institutional dimensions.

Figure 2. Policy and institutional dimensions of sustainable intensification (and CSA) that influence farm systems.

Conclusion: Irrespective of whether the focus is on sustainable intensification or CSA, the likelihood of adoption at scale is going to be strongly influenced by “off-farm” policy and institutional settings. SIMLESA is positively engaging in such matters and is well placed to investigate critical opportunities and barriers to achieving impact at scale. To progress such matters would we valuable co-development from the CGIAR and national agricultural systems. SIMLESA’s “on the ground” experience, partnerships and credibility would be a powerful contribution to the CSA policy space.

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