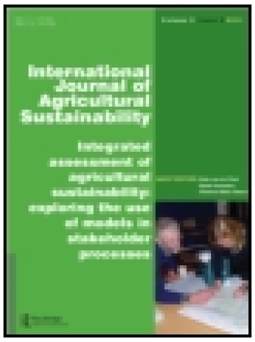


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# Understanding and informing decisions on Sustainable Agricultural Intensification in Sub-Saharan Africa

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INTRODUCTION



# Understanding and informing decisions on Sustainable Agricultural Intensification in Sub-Saharan Africa

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**ABSTRACT**
Sustainable Agricultural Intensification (SAI) was initially defined as increasing agricultural production without adverse environmental impacts and without increasing the area under agriculture. Over time the concept has been broadened to integrate social, economic, and environmental components of sustainability, each of which covers multiple facets or indicators of performance. It is recognized however that it may not be possible to optimize all these aspects of sustainability simultaneously and that trade-offs between them are likely to occur, although synergies are also possible. There has been disagreement over how to achieve SAI, with some proposing that only an 'agroecological' intensification pathway delivers sustainability. Others take a broader perspective arguing that all aspects of ecological, genetic, and socio-economic intensification need to be considered, but then assessed in terms of the sustainability of the outcomes. A major concern is that intensification that focuses on agricultural technology can lead to inequitable outcomes for women and poorer households, while agroecological intensification building upon local capitals is generally considered more equitable. Understanding the potential outcomes and inherent trade-offs of different approaches requires interdisciplinary research, evidence and decision-making tools, some examples of which are presented in this Special Issue.

**KEYWORDS**
Agroecology; equity; environment; food security; sustainability

## Introduction

Africa's population of just over 1 billion in 2010 has an average annual increase of 2.5 per cent and is projected to reach 1.6 billion by 2030 (UNEP, 2013). Over the decade since 2005 agricultural productivity is thought to have increased by about 3.6 per cent per annum (AGRA, 2017). Nevertheless, domestic food production and/or food imports will have to increase to meet the growing and changing food demand due to population growth, urbanization, and a growing middle class (AfDB, 2011; Chandy et al., 2013; UNEP, 2013). Furthermore, chronic hunger on the continent remains high; nearly 23 per cent of the population are classed as hungry, many of whom are farmers owning less than two hectares of land. Smallholder farms in SSA number around 33 million, representing more than 80 per cent of all farms in the region, and contributing up to 90 per cent of food production in some countries (Wiggins & Keats, 2013).

The demands on agriculture are not solely limited to food production but relate to a multiplicity of demands placed upon agricultural lands which occupy around one third of the earth's land surface (Smith et al., 2008). Apart from increasing productivity, to attain food security and meet fuel and fibre needs, agriculture needs to meet a range of other, inter-connected, aims i.e.:

- being resilient to climate change (coping with and recovering from shocks and stresses);

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- supporting the provision of other ecosystem services (for example, climate regulation, water availability and quality) upon which we all depend;
- diversifying away from fossil fuel-based growth, because these resources are finite and their use is a major source of greenhouse gas emissions;
- preventing biodiversity loss and mass species extinction due to agricultural expansion and intensification;
- promoting economic development, poverty reduction, and tackling inequality through rural employment and value addition in developing countries.

Many of these production, poverty and sustainability demands are encapsulated in the United Nation's Sustainable Development Goals. While SAI primarily responds to SDG2 (i.e. *End hunger, achieve food security and improved nutrition and promote sustainable agriculture*) there are also interactions with SDGs (6, 7, 12, 13, 14 and 15) on sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, halting and reversing degradation, stopping biodiversity loss, protecting water sources, and achieving sustainable consumption and energy use.

Although there is widespread agreement that demand for food and other agricultural produce will increase substantially over the coming decades, there is less clarity on how this demand will be met. For example, it is debatable how far demand needs to be met through increases in agricultural productivity, moderating demand through reductions in food waste and changes in diet (primarily reducing demand for livestock products), or changes to the food system to ensure more equitable access to a healthy diet (Garnett et al., 2013). Willett et al. (2019), reporting from the EAT-Lancet commission, conclude that a healthy diet and a healthy environment require the same changes in diet and food production and this should include closing yield gaps in poorer countries and increasing resource use efficiency. Nevertheless, at least for regions with fast growing populations, either increasing food production or massively increasing imports is likely to be necessary (van Ittersum et al., 2016). The challenge is how to achieve increased production, while delivering on other sustainability imperatives.

In this context the UK Department for International Development (DFID) funded the Sustainable Agricultural Intensification Research and Learning Programme (SAIRLA). Combining research and learning, the programme has sought to inform stakeholders and decision-makers in sub-Saharan Africa (SSA) about constituting an effective enabling environment to facilitate and ensure that poor African smallholder farmers, especially women and youth, benefit from SAI and agricultural development.

## Defining sustainable agricultural intensification

Definitions of Sustainable Agricultural Intensification have evolved, becoming broader over time, but are still contested. An early definition of SAI was provided by the Royal Society: 'yields are increased without adverse environmental impacts and without the cultivation of more land' (Royal Society, 2009). Later, Pretty (2008) described SAI as 'intensification using natural, social and human capital assets, combined with the use of best available technologies and inputs (best genotypes and best ecological management) that minimize or eliminate harm to the environment'. The Montpellier Panel (2013) expanded on Pretty's definition to consider intensification as producing more outputs (production) with more efficient use of inputs on a durable basis, while reducing environmental damage and building resilience, natural capital and environmental services. The IIED review of SAI (Cook et al., 2015) also highlights the importance of wider considerations of sustainability than earlier definitions allowed for, especially including social as well as economic and environmental dimensions. Further development of the concept has included emphasis of the importance of considering SAI within the wider sustainable food system (Cook et al., 2015; Garnett et al., 2013). Although Godfray (2015), has argued that SAI should be defined by the central tension between the intensification of production and environmental sustainability, many reviews now include social, environmental and economic sustainability components as essential to the term (Mockshell & Kamanda, 2018).

Expanding on the traditional three pillars of sustainability, Smith et al. (2017) group indicators of sustainable intensification in smallholder agriculture, found in the literature, into five categories: Productivity, Economic Sustainability, Human Wellbeing, Environmental Sustainability and Social Sustainability. Each of these categories is composed of six to eight indicators and an even larger array of metrics that have been used to assess sustainability. More importantly they recognize the high probability of trade-offs, although also synergies, in the performance of agricultural systems across this range of indicators. These trade-offs and synergies may occur at different temporal or spatial scales.

Broad-ranging definitions of sustainable agriculture are more inclusive, but they can be problematic in terms of providing practical guidance for implementation, and so decision-support-tools may be helpful. The multi-faceted nature of the issues being considered, as well as the diversity of agricultural systems and environments, in particular in SSA, can make it hard to identify priorities for action and to understand the likely outcomes of interventions. Gold (2007) cites discussions on sustainable agriculture that suggest the inherent characteristic of a multiplicity of dimensions impedes practical application and so decision-makers should identify sustainability issues of priority and use up-to-date information about the trade-offs involved using a multiple criteria decision-making formula. However, such an approach does not necessarily address issues of power inequalities in the implementation of SAI as well as in the distribution of outcomes. Who decides which issues are important and need to be tackled and which should be deprioritised? Who benefits and who loses from specific trade-off decisions? The risk is that those holding power can choose those aspects of sustainability of greatest interest to them and disregard others. Therefore, the framing of options within a decision-making tool becomes important.

We conclude that SAI is best defined as a multidimensional outcome of increasing agricultural productivity while maintaining social, economic and environmental sustainability; recognizing that each of these aspects individually encompass multiple elements. This is similar to how climate smart agriculture has been defined; i.e. by the expected outcome of increasing food security, adaptation and resilience while reducing greenhouse gas emissions from agriculture (Lipper et al., 2014). SAI and CSA are closely interlinked concepts and all cases of CSA invariably turn out to be cases of SAI. Since the relative priority of each objective varies across locations, with for example greater emphasis on productivity and adaptive capacity in low-input smallholder farming systems in least developed countries, an essential element of CSA is identifying potential synergies and trade-offs between objectives (Campbell et al., 2014). The existence of trade-offs between elements of these dimensions means that maximum benefits across all are unlikely to be achieved. Instead, the goal should be to optimize the benefits across these dimensions, but with a clearer recognition of the equity and values-based dimensions involved and of the importance of democratic processes in trade-off decision-making.

## Pathways to achieve SAI

While defining SAI has been complex, how to achieve it has been even more contested. Different analyses (Godfray, 2015; Mockshell & Kamanda, 2018) have seen this as a choice between two competing world views on agricultural development. The term SAI has been conflated by many observers with a high-input, agro-biotechnological pathway of intensification, while Agroecological Intensification (AEI) is frequently associated solely with the application of ecological principals to agricultural production as an alternative to the use of agrochemicals and genetically modified germplasm. Some propose that only an AEI pathway would deliver sustainable outcomes as it makes use of locally available resources and ecological processes, and retains greater local ownership of resources. Others suggest that a high-input, agro-biotechnological pathway of intensification would make the most efficient use of available resources and therefore likely be the most sustainable approach. Acceptance of GMOs has been viewed as one of the primary technological distinctions between AEI and SAI; but GMOs only represent part of the array of technologies which can be considered under SAI, AEI seeks to work solely with locally adapted germplasm.

Biotechnology-based genetic improvement or change, in certain circumstances may provide potential opportunities to address some of the limitations on agricultural productivity and to reduce environmental impacts. The environmental, social, and economic impacts of GMOs is a highly contested field, as are the broader political economy implications. Recent assessments of the impacts of GMO crops on agro-ecosystem processes indicate that there can be both positive and negative ecological consequences of their use, but that the impacts overall are not different in nature to other changes in agronomic practice (Kolseth et al., 2015). Others promote interventions that support the strengthening of both formal and informal seed systems that respond better to smallholder needs of diversification, resilience, and post-harvest characteristics (McGuire &

Sperling, 2016). Studies have shown that farmers in Africa access over 90% of their seed from informal systems with about half purchased from local markets (McGuire & Sperling, 2016). Due to lack of local capacity to develop, reproduce and distribute improved seed, improved varieties are often imported from outside and therefore lack good adaptation to African production conditions, particularly those of smallholders. Assessment of the above has led to initiatives such as New Rice for Africa (NERICA) that sought to combine the improved productivity characteristics of improved varieties of the Asian species (*Oryza sativa*) with the resilience of varieties of the African species (*O. glaberrima*), by breeding interspecific hybrids between the two (Wopereis et al., 2008).

SAI has also been associated with the continued use of agrochemicals, albeit in a more efficient fashion (Mockshell & Kamanda, 2018). Use of agrochemicals is highly variable across the globe and generally low in Africa, although it is increasing, and there are cases of misuse and over-use (e.g. Rodenburg et al., 2019). Better management of ecological processes is essential to improving productivity and making agriculture more sustainable – and this includes the more effective use of agrochemicals, in combination with practices that maintain good soil health. In Africa, it is unlikely that intensification can be achieved without some rational use of agrochemicals, but their usage could potentially be combined with agro-ecological methods and biotechnological innovations such as improved varieties and breeds.

One of the key concerns pertaining to certain technological pathways to intensification (which involve the use of agrochemicals and genetically improved seed) is the power of agro-industrial companies. While agro-industrial companies gain greater power with increasing concentration, smallholder bargaining power remains weak. There are thus valid concerns as to how smallholder farmers can engage in technological, agribusiness-based pathways to intensification given power imbalances and capacity issues, such as the lack of smallholder organization and weak bargaining power vis-à-vis large companies (Bolwig et al., 2010). The more economically and socially disadvantaged smallholders are, the more challenging it becomes for smallholder farmers to participate in markets and fairly capture benefits from their participation in value chains. Further, with processes of commercialization in agriculture there are risks that already marginalized groups can be further excluded.

While some observers have linked genetic intensification with the use of agrochemical inputs typical of the 'Green Revolution' (e.g. Gregory et al., 2002), other scholars and practitioners consider that different approaches to SAI need to be combined to achieve the dual aims of sustainability and intensification of agriculture (Godfray, 2015). The Montpellier Panel (2013), a group of European and African experts identified three 'practical approaches' to intensification, namely: (i) ecological intensification (agroecological practices); (ii) genetic intensification (yields, nutrition and resilience to pests and diseases) and (iii) socio-economic intensification (human, social and market capital), as proposed by Conway (2012). These approaches are not seen as mutually exclusive by the Montpellier Panel (2013) – indeed it is the combination of all three that is most likely to enable achievement of SAI. A blended form of agricultural intensification, as advocated by Mockshell and Kamanda (2018), whereby complementarity rather than competition between SAI and AEI is sought, therefore seems a potential viable approach for SSA, although political economy issues remain a consideration.

How these intensification components are combined might lead to different agricultural intensification pathways such as agroecological or green revolution approaches, or an intermediate SAI approach. Each differ in their use of social, human, economic, and natural capital to intensify production, and are likely to lead to different outcomes in terms of productivity and sustainability. However, there may be social, environmental, economic and political trade-offs in combining approaches. These trade-offs are at the heart of the perception of agroecological pathways as favouring smallholders and genetic/agrochemical intensification pathway as favouring commercial interests. Collier and Dercon (2009) have recognized the contested and polarized nature of many of the preceding debates on smallholders and productivity and call for more 'open-minded approaches to different modes of production'.

## Pathways for agricultural development and their implications for SAI and equity in Africa

Debates on sustainable agricultural development in Africa have also been somewhat polarized in recent years. On the one hand, some observers view small-scale farming as the future (as a driver of economic development and poverty reduction), while others promote large-scale commercial investments in agricultural development as the means to these same ends. The post-millennial decade saw a re-emergence of the smallholder-led model of agricultural growth, alongside continued support from development agencies and some governments for large-scale land investments, albeit with increased attention to business models avoiding transfers of land (e.g. outgrower schemes). The refocus on smallholders in some quarters has been based on the fact that they are responsible for the majority of agricultural production in SSA (Lowder et al., 2016), and the conviction that smallholders, if given the necessary commercial incentives and technological inputs, can enhance their own food security as well as ensuring a surplus for growing urban markets. More recently, however, increased recognition of the differences within the smallholder sector and growing land fragmentation has led to fears of the marginalization of weaker groups such as women and youth in smallholder agriculture (Andersson Djurfeldt, 2018; Jayne et al., 2014).

Recent work has identified the uneven nature of the policy playing field for smallholder farmers. An Oxfam and IIED report (Vorley et al., 2012) finds that despite widely varying contexts, current policy levers (e.g. public-private partnerships, tax incentives, support for individual rather than collective land rights) favour larger-scale commercial operations. In addition, these levers are 'non-inclusive' in nature and therefore disfavour small producers. Debates continue as to how to make smallholder agriculture work. Hazell et al. (2007) suggest that the promotion of growth and equity of smallholder agricultural development would require: (i) getting the basic infrastructure and institutional conditions in place, (ii) encouraging farmers to follow demand and improving marketing systems and (iii) innovation in providing inputs and services. Even if policies are appropriate on paper, they may not be implemented for a variety of reasons, such as divergence between government and donor policy beliefs, a lack of government capacity to implement and monitor them.

Large-scale agricultural investment has attracted support from investors, donors, and governments in Africa in recent years. Large investments can offer 'good returns and linkages with local economies' (Locke & Quan, 2016), but there are often operational challenges because of land conflicts, and the empirical evidence clearly indicates that the outcomes are highly uneven and differentiated, and often highly negative for local smallholders and communities (see Nelson et al., 2020). Large farms can significantly reduce transaction costs for buyers and higher up supply chains. In recent years there has been substantial research on the challenges of land acquisition and speculation by large companies and investors (for example, see Cotula, 2011) and concerns relating to the non-observation of key principles such as Free and Informed Consent in many cases leading to inequitable effects for local communities. Some donors are seeking to support new 'sustainable' business models that can reduce risks for large investors, but which also deliver on sustainability imperatives (for example, reduced deforestation due to agriculture). These, however, are at an early stage of intervention and there are likely to be pre-conditions for success, including strengthened property rights for marginalized groups and support for capacity strengthening for farmer groups. Large farms are often associated with less environmentally sustainable practices, but the extent to which this is necessarily true in practice should also be reviewed empirically (Baker, 2013). Larger land holders may have more resources to invest in environmentally sustainable production if there is a clear business case, enforced regulatory requirements or a strong personal commitment. However, the environmental outcomes need to be proven and to take into account the biodiversity aspects of land use change at the landscape level both for large-scale farming and the cumulative impacts from smallholders.

A more nuanced approach is necessary because of an increasing gap between subsistence smallholders and more business-focused smallholders. Regarding the latter, a 'farming as a business' approach is currently promoted by many donors and development agencies in SSA agriculture. Hazell and Rahman (2014) argue that there is an increasing gap between subsistence smallholders and those smallholder households that have more resources to engage in more business-focused activities, such as non-farm income generation. The problem of land fragmentation and increasing inequality in farm sizes is widely and increasingly recognized (e.g. Lindjö et al., 2020). Further, moving beyond a dualistic view of land holding in SSA, the emergence of medium-scale African farmers is a clear trend that is not yet widely recognized by observers and policy-makers. An analysis of available empirical evidence reveals that farm size holding is more differentiated than previously recognized (Locke & Quan, 2016; see also Adolph *et al*, 2020). Another important associated trend is an increasingly high proportion of land holdings being owned by urban-based households (e.g. 32% in Kenya in 2014 and 33% in Tanzania in 2010; Jayne et al., 2016). Policymakers therefore need to design their policies to more closely reflect this emerging, more complex and spatially varying reality.

In some cases, proponents suggest that African smallholder development can both drive or sustain growth and deliver more equitable development outcomes (Hazell et al., 2007). In other cases, policymakers need to consider whether there are social reasons to support small farms. If not, the policy agenda should involve establishing social safety nets for the poor and more proactively facilitating 'good' exits from farming for smallholders (Hazell et al., 2007).

One specific area requiring policy attention, to facilitate the development of investments, is land tenure. To ensure equitable land transactions and transfers are facilitated (Locke & Quan, 2016) requires investment in land governance and investment processes, especially community legal capacity strengthening and observance of Free, Prior and Informed Consent in all land investments. Achieving equitable development requires measures to ensure a just and fair distribution, such as strengthened property rights, fair land transactions and aligned national development strategies. However, such equitable development aims do not necessarily mean that all smallholders could, should or will stay in agriculture.

## How to understand SAI and make decisions?

The discussion above shows that SAI is a complex concept which involves different aspects of the agricultural system. It involves a multitude of agronomic options, environmental processes, scales of intervention and socio -economic, political and environmental outcomes. What has been lacking is clarity on the transition processes involved – what interventions, lead to what kinds of changes, and what are the outcomes? There are many differing SAI interpretations and pathways, and so the nuances are frequently lost and the debate remains polarized.

Weltin et al. (2018), drawing upon a review of literature identified different 'fields of action' possible to achieve SAI, which are inclusive of different potential socio-technological pathways. The first field of action is 'agronomic practices' which includes all aspects of crop and livestock management including selection of germplasm, cultivation, fertilization/feeding. The second field of action is 'resource use efficiency' through structural optimization of use of natural resources such as water, nutrients, feed, but also knowledge and labour, to improve productivity per unit resource and minimise environmental contamination. The third field is 'land-use allocation' to improve and maintain the balance between agricultural and non-agricultural uses, and the resultant ecosystem services and biodiversity. The fourth field is 'regional integration' which covers the knowledge, institutions, governance, and multi-stakeholder networks required to provide an enabling environment for SAI. The latter field highlights the importance of knowledge or evidence as to what the outcomes of an intervention may be, and the institutions, instruments, and capacities to act on that information.

Nelson et al. (2020) integrated the framework of Weltin et al. (2018) into a theory of change on SAI in sub-Saharan Africa creating an overarching visualization of SAI (Figure 1). It shows how a diverse set of agricultural system actors, who are bounded by rules and structures and influenced by varied drivers at different scales, make decisions on agricultural and land use trade-offs. The resultant change processes, characterized by intensification of production, involve different configurations of agronomic and resource use efficiency at farm and local scales, plus shifts in land use allocation and levels of regional integration at regional scales. Such changes may be more or less transformative in nature, and will have differing equity implications. Combined, this leads to differing outcomes (economic, social and environmental), of varying resilience in the context of a changing climate. This theory of change, which also shows change over time, involves many implicit assumptions, and many of the changes will not be linear in practice. However, it provides a useful heuristic for thinking about the nature of sustainable agricultural intensification, keeping in view the role of structures and the agency of different actors in different types of decision-making across scales – all of which leads to complex and context-specific outcomes.

## Special issue on enabling SAI

The papers presented in this Special Issue focus on the knowledge of how to enable SAI, and above all how to enable SAI that is both sustainable and equitable. Results from projects funded by the Sustainable

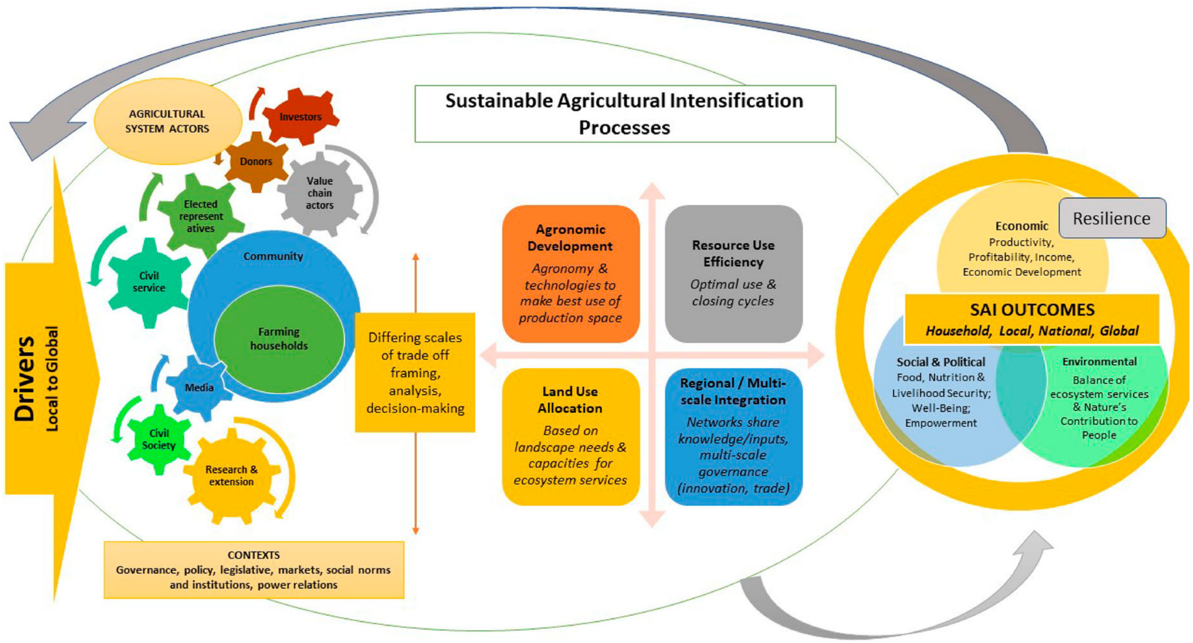


**Figure 1.** Theory of change for Sustainable Agricultural Intensification showing the drivers which catalyse change, the actors in the agricultural system, the contextual factors which shape their decision-making and the wider ecological and social system in which they are embedded. As actors make decisions at different scales these lead to trade-offs and synergies which create processes of intensification. These processes create complex, context-specific outcomes in socio-political, environmental and economic dimensions.

Agricultural Research and Learning in Africa Programme supported by DFID are presented and the special issue is structured around the themes of Equity, Trade-offs and Services.

- The first set of papers present evidence on the equity of outcomes of SAI for different gender and generational groups in particular access to land and the services and resources to intensify production (Fischer et al., 2020; Lindjö et al., 2020). Decision makers need to use appropriate indicators, data collection methods and tools to reveal those differentiated outcomes to support decisions on addressing inequities (Grabowski et al., 2020, Zulu et al., 2020).
- The second group of papers recognizes that there are trade-offs in the outcomes from SAI at all levels of decision making from farmers to national decision makers. Evidence is needed to understand the nature of these trade-offs for farmers attempting to implement and adapt SAI practices within local contexts (Adolph et al., 2020; Rodenburg et al., 2020). Multi-stakeholder processes supported with information and tools are needed to help to manage and support decisions between pathways to achieve SAI (Morris et al., 2020).
- Thirdly, farmers and other stakeholders need access to services and information to support effective implementation of SAI. ICT tools have a potential role to play in improving such access, but need to be better tailored to farmers' needs and capacities (Ortiz-Crespo et al., 2020; Steinke et al., 2020). Effective use of combinations of communications media can contribute to increased knowledge and uptake of practices by farmers (Silvestri et al., 2020). Environmental and economic risks also affect effectiveness of services, which can be revealed by games that test different scenarios (Orr et al., 2020).

The SAIRLA programme with partners across Africa has sought to bring evidence and tools to decision-makers as part of a learning alliance to integrate and apply these lessons to the implementation of agricultural policies and practices.

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No potential conflict of interest was reported by the authors.

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