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Bringing evidence to bear for negotiating tradeoffs in sustainable agricultural intensification using a structured stakeholder engagement process

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ABSTRACT

Sustainable agricultural intensification (SAI) has the potential to increase food security without detrimental effects on ecosystem services. However, adoption of SAI practices across sub-Saharan Africa has not reached transformational numbers to date. It is often hampered by lack of context-specific practices, sub-optimal understanding of tradeoffs and synergies among stakeholders, and lack of approaches that bring diverse evidence sources together with stakeholders to collectively tackle complex problems. In this study, we asked three interconnected questions: (i) What is the accessibility and use of evidence for SAI decision making; (ii) What tools could enhance access and interaction with evidence for tradeoff analysis; and (iii) Which stakeholders must be included? This study employed a range of research and engagement methods including surveys, stakeholder analysis, participatory trade-off assessments and co-design of decision dashboards to better support evidence-based decision making in Zambia, Tanzania and Ethiopia. At the inception, SAI evidence was accessible and used by less than half of the decision makers across the three countries and online dashboards hold promise to enhance access. Many of the stakeholders working on SAI were not collaborating and tradeoff analysis was an under-utilized tool. Structured engagement across multiple stakeholder groups with evidence is critical.

KEYWORDS

Sustainable agricultural intensification; stakeholder engagement; SHARED; evidence-based decision making; tradeoff analysis

Introduction

Multi-functional smallholder farming systems in East and Southern Africa (ESA) are highly diverse in terms of climates, land uses, land cover types, governance structures and socio-economic realities. Increased demographic pressure and a growing demand for food is putting more pressure on these food systems, often resulting in severe land degradation and reduced adaptive capacity to climate change. Smallholder farmers are responsible for the vast majority of agricultural production in ESA, but the most of these farmers remain poor and marginalized (Salami et al., 2010). Decades of economic growth throughout ESA is reshaping food systems as urbanization and demographics impact agricultural production and markets. There is

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therefore a need for action throughout the food system. Sustainable agriculture intensification (SAI) aims to increase food production from existing farmland while avoiding negative environmental, social or cultural impacts (Garnett et al., 2013; Pretty, 2008). While some argued that SAI focused too much on intensification, the concept of ecological intensification aims to intensify the biological regulation on the system, building on the supporting and regulating ecosystem services (Doré et al., 2011; Tittonell, 2014). Ecological modernization acknowledges the role of agro-ecological approaches and aims to address institutional barriers to implementation (Horlings & Marsden, 2011). Given these holistic perspectives, the definition of SAI continues to be refined and adapted, for example, to be more inclusive by making sure that the human and social considerations were also taken into account so that not only food production was prioritized (Liao & Brown, 2018; Loos et al., 2014). A paradigm shift around SAI has been proposed where agriculture contributes to a 'sustainable world within a safe operating space on Earth' (Rockström et al., 2017). Most recently the global commission on agriculture supported the articulation of the role of agroecology to build resilience to climate change and contribute to the provision of multiple ecosystem services (Sinclair et al., 2019). Despite their differences, these various approaches are a response to the severe environmental and social short-falls of the Green Revolution (Conway & Barbie, 1988) and the negative impacts of conventional agriculture on ecosystem services (Matson, 1997; Tscharntke et al., 2012).

In multifunctional agricultural landscapes, tradeoffs occur both within and between agricultural systems, across broader environmental or socio-cultural objectives, across temporal and spatial scales, as well as between actors (Klapwijk et al., 2014). Given the multiple objectives and domains within SAI, it inevitable that tradeoffs will need to be considered. Thomson et al. (2019) outlined key aspects that need to be addressed in SAI, including context-specific trade-offs and the need for reliable evidence in order to quantitatively assess these multiple dimensions. Several methods have been developed to analyse tradeoffs, including participatory approaches, empirical analyses, optimization models and simulation models (Antle et al., 2003; Folke et al., 2016; Haggar et al., 2017; Kanter et al., 2018; Musumba et al., 2017). Despite, these numerous methods, there is often a gap in how these data and outputs are shared and communicated with the various stakeholder groups, especially those prioritizing and investing in SAI. We also know that approaches that engage policy makers, farmers, and other stakeholders in collaborative processes to facilitate interactive dialogue with data and evidence at appropriate scales are more successful than traditional 'linear' ways of communicating science and evidence (Young et al., 2014). This is critically important in the promotion of SAI, particularly given that it requires the acquisition of new knowledge, skills and attitudes amongst producers, coupled with adoption of fundamentally new ways of managing their farming systems.

However, the opportunities for many smallholders, especially women and young people, to benefit from this transition through SAI remain elusive. Lack of information and evidence about locally appropriate technologies, market interventions and enabling policies are often cited as key reasons for the failure of development approaches to foster innovation and transform agriculture in SSA. Extension systems and NGOs operating technology transfer models have generally failed to take sufficient account of the various socio-economic and environmental tradeoffs amongst different agricultural management options, or to sufficiently incorporate local knowledge and variation in context (Coe et al., 2014; Waters-Bayer et al., 2015). As much as the aim of SAI is to increase production efficiency, farmers and other stakeholders need to understand potential tradeoffs between agricultural inputs and biological processes that impact key ecosystem services (Pretty et al., 2011). Others suggest that SAI approaches embrace a farmer-centered approach, encourage constructive communication across multiple stakeholders, and development of a conducive policy environment (Barrett et al., 2002). Suggestions to support this scaling include an 'agricultural system redesign' which incorporates policy measures to support SAI, building of social capital and innovation around SAI practices (Pretty et al., 2018). As SAI continues to gain momentum, many argue there are still knowledge gaps to be addressed, as highlighted by the identification of the most pressing research questions facing global agriculture (Pretty et al., 2010) and the most recent analysis which calls for 'adequate investment and effective R&D prioritization' (Cassman & Grassini, 2020). Therefore, it is clear that stakeholder engagement along the entire process from SAI prioritization to evidence generation and dissemination is critical to its successful implementation.

The importance of stakeholder engagement for scaling agricultural innovations has long been recognized. Understanding which stakeholders to engage and their perspectives and interests is critical for work related to sustainability and to ensure legitimacy and quality of related decisions (Prell et al., 2009). Grimble and Wellard (1997) defined stakeholder analysis as a holistic approach or procedure for gaining an understanding of a system, and assessing the impact of changes to that system, by means of identifying the key actors or stakeholders and assessing their respective interests in the system. Engagement of stakeholders is also critical to understand the complexity in both accountability and decision-making processes (Frame & Brown, 2008), which is highly relevant to SAI. Cvitanovic et al. (2016) emphasized the importance of knowledge exchange among scientists, decision makers and stakeholders to enhance decision making. Social network analysis can be used to enhance stakeholder analysis by focusing on the connections between social entities (Prell et al., 2009; Wassermam & Faust, 1994) as well as to identify the role of the various stakeholder groups (Mitchell et al., 1997; Prell et al., 2008). Brugnach and Ingram (2012) recognized that shared knowledge systems among stakeholders include diverse sources of experience, scientific facts, meanings and interpretations. Other authors have outlined a framework for identifying entry points within complex stakeholder engagements and agricultural innovation support systems (Schut et al., 2015). However, very few outline the specifics of multi-stakeholder engagement, including the need to work across multiple administrative policy levels along with systems thinking to enhance decision making around agricultural innovations. Systems thinking perspectives among citizens and decision makers is considered critical to dealing with complex issues in development (Arnold & Wade, 2015). Bringing these together into a decision making framework that takes into account systems thinking; cross-sectoral, multi-stakeholder and multi-scale interaction; and visually accessible evidence has been undertaken using the Stakeholder Approach to Risk Informed and Evidence Based Decision Making (SHARED) method to support integrated planning and implementation in socio-ecological systems (Neely et al., 2017; Vågen et al., 2018).

This paper shares insights from an interdisciplinary research project within the Sustainable Agricultural Intensification Research and Learning in Africa (SAIRLA) Programme. SAIRLA is a five-year programme (2015–2020) which aims to generate new evidence and design tools to enable governments, investors and other key actors to deliver more effective policies and investments in SAI. This specific project aimed to increase the uptake of context-appropriate SAI innovations in ESA through evidence generation, data analytics, farmer engagement and the development of innovative tools for stakeholder engagement with evidence, including the assessment of tradeoffs. Research questions included: (i) What is the accessibility and use of evidence for SAI decision making; (ii) What tools could enhance access and interaction with evidence for tradeoff analysis; and (iii) Which stakeholders must be included?

The specific objective of this paper was to show the role of structured stakeholder engagement processes to negotiate tradeoffs and synergies of SAI across multiple stakeholder groups. This includes the process of bringing together stakeholders, allowing them to share their perspectives on practices and policy development around SAI, access to credible evidence sources, role of social networks, and finally the utility of open access decision dashboards to share evidence and target SAI interventions.

Materials and methods

Study area

The project was implemented across multiple scales (farm, district, national) in three countries, Ethiopia, Tanzania and Zambia (Figure 1). Farmer-level engagement and implementation of on-the-ground field activities took place in the Solwezi district in the 'new Copperbelt' region of Zambia, specifically in Mutanda and St Francis wards. In Tanzania, activities were based in Mbarali district in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). In Ethiopia, activities took place in Ziway, Meki, and Mojo woredas in the rift valley in the Oromia region in southern Ethiopia. National-level activities took place in Dar es Salaam, Tanzania; Lusaka, Zambia; and Addis Ababa, Ethiopia. The action areas were chosen as hotspots of demand for the development, testing and dissemination of context-specific SAI interventions, as explained in detail below.

In Tanzania, the SAGCOT is one of several agricultural 'growth corridors' being proposed in SSA. It covers an area corresponding to about one-third of

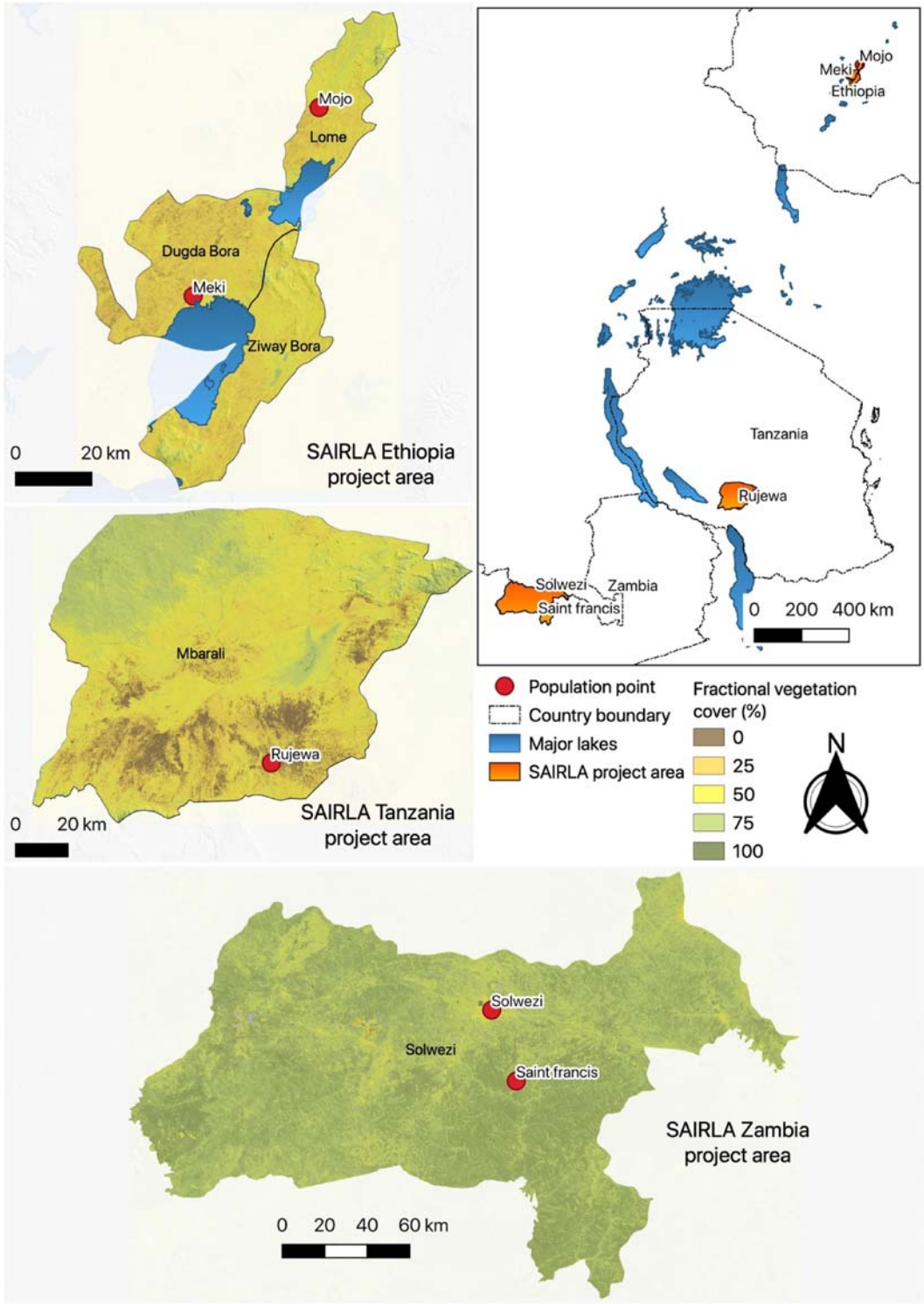

Figure 1. Location of the action countries (top right) and specific districts of implementation.

mainland Tanzania and extends from Dar es Salaam to the borders of Zambia and Malawi. This region has a growing, government-led emphasis on SAI with a focus on increasing agricultural production. The main crop grown in Mbarali district is rice, followed by maize and tomatoes.

In Ethiopia, Meki, Mojo and Ziway woredas are important zones for agriculture, especially due to the their close proximity to Addis Ababa. Main crops include maize, wheat, and haricot bean, with areas adjacent to Lake Ziway and Bulbula river irrigated for vegetable farming and horticultural crops. Mean annual rainfall is 750 mm with a monomodal distribution. Some of the key concerns to agricultural sustainability in this region, particularly in irrigated areas, include high soil pH and increased salinization, as is the case in much of the Rift Valley in East Africa.

In Zambia, the Solwezi district has favourable rainfall (1000–1500 mm yr^{-1}) with high potential for agricultural production, but biophysical conditions constrain crop and livestock production. Subsistence agriculture, using the Chitemene system of shifting cultivation, is the main livelihood activity. Major crops grown in the area include maize, cassava, rice and potatoes and major cash crops include tobacco, cotton and horticulture. The natural vegetation is miombo woodland, which is also an mportant sources of food and income, particularly game, timber, fuel and honey.

The project combined several process and technical approaches in building the evidence base for SAI in each of the countries and for sharing of evidence in a format useful for decision making and SAI practice by diverse stakeholders at multiple scales. The project conceptual framework is provided in Figure 2.

Stakeholder approach to risk informed and evidence based decision making (SHARED)

The Stakeholder Approach to Risk Informed and Evidence Based Decision Making (SHARED) method is a tailored process that builds on rigorous scientific data and evidence to facilitate interaction between people and accessible evidence for planning and decision making that yield sustainable impacts. SHARED is an approach guided by a set of principles and adapted to each case with appropriate tools applied. SHARED is a people-centered and demand driven process with deliberate dialogue and communication to encourage co-learning and negotiation. Furthermore, SHARED aims to enhance decision making capacities for transformative tools.

In this study tools included stakeholder mapping, continuous stakeholder engagement across the lifetime of the project, participatory tradeoff analysis, data collection in the field, facilitated interaction with evidence and the co-development of the decision dashboard. The roadmap to building the evidence base and co-designing the dashboards started at the inception of the project, with the initial National SHARED workshops in September 2016, subsequent workshops at the district level in 2017 and National SHARED workshops in 2017. As well as repeated engagement with the National Learning Alliances (NLAs) in each country. All these engagements and interactions culminated in the SHARED workshops on the SAI Dashboards.

Stakeholder mapping and survey on evidence access and use

Stakeholder mapping was used to identify key stakeholders to be included in workshops and to identify the level of connectivity of the network and where stakeholders were disconnected. As such social network analysis (SNA) was used to display and analyse stakeholder information networks using the R-Studio igraph package (Csardi & Nepusz, 2016). SNA is a powerful visualization tool and has been used as it moves beyond the limitations of categorizing stakeholders based on categories such as power and interest to review their role in communication networks and to review stakeholder relationships (Prell et al., 2009).

A stakeholder mapping exercise, using social network analysis (SNA) and a survey of access to and use of evidence for SAI decision making took place during a sub-national participatory workshop in 2016 and subsequently with national level stakeholders in Ethiopia, Tanzania and Zambia. Stakeholder profile information was collected using the SHARED Stakeholder Mapping Guide (Bourne et al., 2017). Trained enumerators interviewed respondents individually at the national level and at workshops for the sub-national level. Respondents represented key organizations engaged in SAI and were identified by key informants and literature. An electronic data entry form, using Open Data Kit (ODK), was developed, enabling rapid and high-quality data collection. These data were collected and uploaded to the ODK Server hosted at World Agroforestry (ICRAF)

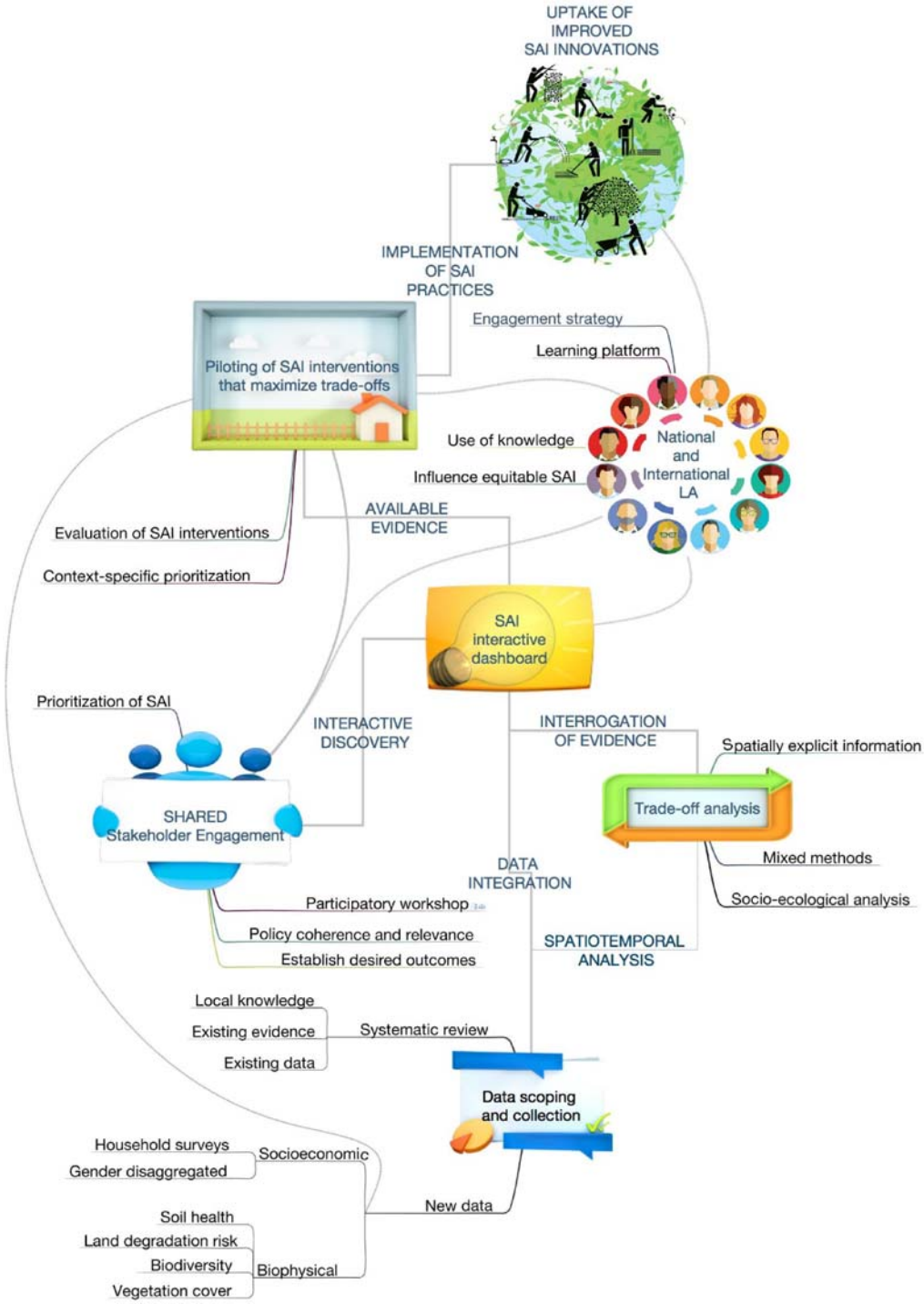

Figure 2. Conceptual framework of the project.

GeoScience Lab. Social network information was collected using the ODK tool for national level respondents and using a paper form for the sub-national workshop participants.

Participatory tradeoff activity workshops at local and national level: including capacity development

A participatory tradeoff activity was developed and implemented with stakeholders at both district and national level in Ethiopia, Tanzania and Zambia during the second SHARED workshops. The purpose of the activity was threefold: (1) To gather perspectives on the impact of SAI practices on various socio-ecological domains; (2) Identify key data needs to assess tradeoffs and synergies; and (3) Identify key areas for action to minimize tradeoffs. The tradeoff activity was adapted from the Guide for the Sustainable Intensification Assessment Framework (Musumba et al., 2017) and employed a stepwise approach to assessing the influence of SAI practices on the five suggested dimensions of SAI (agricultural productivity, income, land health, human condition and social aspects). Before embarking on the tradeoff activity, an exercise on what a tradeoff is, and how to interpret a radar graph was developed and implemented. This was an important step to facilitate a better understanding of the concepts of tradeoffs.

Each indicator was scored from −5 to −1 for negative influence, 0 for no influence, and 1–5 for positive influence. The results of the scoring exercise were then aggregated at the dimension level and visualized using a radar plot. Based on the scores, the stakeholders identified which dimensions and indicators needed the most attention to reduce the negative influence of the SAI practice, as well as the specific investments needed to overcome these potential barriers. Recommendations from resulting discussions outlined the next steps needed to integrate tradeoff assessments into SAI planning processes in the target countries. Furthermore, key data gaps tthat need to be filled in order to conduct robust tradeoff analysis were identified.

Co-development of SAI dashboards and feedback

The project aimed to develop an interactive, open access platform – 'SAI Dashboard' – for project action sites to support the engagement of decision makers to interact with data and evidence. The objectives of the SAI dashboard were to: (1) store, access and share available SAI data online; (2) visualize data in a way that is easy and quick to understand; (3) view data on multiple topics at the same time to support decision making; (4) enhance capacity to interpret, discuss and use dashboard data; and (5) enhance capacity to make tradeoff considerations when planning SAI interventions and policies. The dashboards contain both social and ecological data sets and use spatial and non-spatial data analytics and graphics to present the data to users. Along with advanced data analytics and visualization tools, the SAI dashboards provide tools for in-depth exploration of models, data, information and can be used for hypothesis testing. The roadmap to building the evidence base and co-designing the dashboards started at the inception of the project and continued throughout the life of the project.

The first step was the identification of key modules to be developed within each SAI Dashboard, for example, from yield datasets to land health assessments. Next was the participatory identification of the data sources that are available to be included under each of these modules. These activities were carried out during the SHARED workshops at the inception of the project.

To encourage sustainable use of the dashboards, with intended embedding into planning structures, a Core Dashboard Team was self-nominated during the workshops with drafted terms of reference and guidelines for communication and feedback mechanisms. This core team acted as focal point within the countries, so that co-designed dashboards could be continually updated and iterated with decision makers needs around SAI. Over the subsequent year, further interactions took place to allow key feedback, refinement in design and capacity support, both in interpreting evidence, as well as decision and negotiation support, specifically applicable where tradeoffs across scales have to be captured.

Dashboard feedback tool

A structured dashboard feedback form was developed to elicit feedback on the utility and functionality of the dashboards during interactions with the dashboard. Feedback was given around features that the stakeholders found of interest, ease of navigation within the dashboard, useful modules and visualizations within the dashboard, suggestions for additional modules that could be included in the dashboard, who the users of the dashboard are, and the decisions that the dashboard would be most useful to inform. The feedback was collected in different settings including during the national SHARED workshops and was incorporated in continual improvement of the dashboards.

Participants to each workshop filled the dashboard feedback form ranging from NGOs, government, research, donor organizations as well as the private sector ($N = 37$ in Zambia; $N = 43$ in Tanzania; and $N = 43$ in Ethiopia). The feedback form asked the following questions: *(1) Which features caught your attention? Please list and describe key features you found interesting and why; (2) Did you find it easy to navigate around the dashboards and access information? Please give direct recommendations for changes; (3) What modules and data visualization did you find most useful? And why?; (4) Are there additional modules that should be included in the SAI dashboard that would support your work? Please list the modules; (5) Who do you think the dashboard is most useful for and why?; and (6) What decision(s) do you think the dashboard would help inform?*

Results

SAI evidence access and use

Of the 124 SAI stakeholders identified and interviewed for the baseline survey on evidence access and use, nearly 60% were considered to hold significant decision-making power, i.e. they worked for government institutions that set SAI relevant policy; designed or managed SAI-relevant programmes, projects and interventions; or occupied senior decision-making/ management positions within these organizations. Eighty-one percent were men and 19% were women. There was equal participation of stakeholders across the countries (41 participants from Ethiopia, 45 from Tanzania and 38 from Zambia). Participants were from various institutions including government (representing 48% of the respondents), Non-Governmental Organizations (NGOs) (18%) and private sector (7%), among others (Figure 3).

The results of the survey revealed that, while about 40% of the interviewed stakeholders perceived that they had access to general SAI information and evidence and informed their policies and programmes accordingly (Figure 4) more refined information and evidence was lacking (average of 11%) on what works where (e.g. in specific local contexts) and for whom (e.g. for women and other differentiated social groups) (Figure 5). Although almost half of the SAI decision-makers reported that their organizations incorporate SAI related information into their decision-making, far fewer do so with respect to more nuanced evidence pertaining to women and men and specific social groups and contexts.

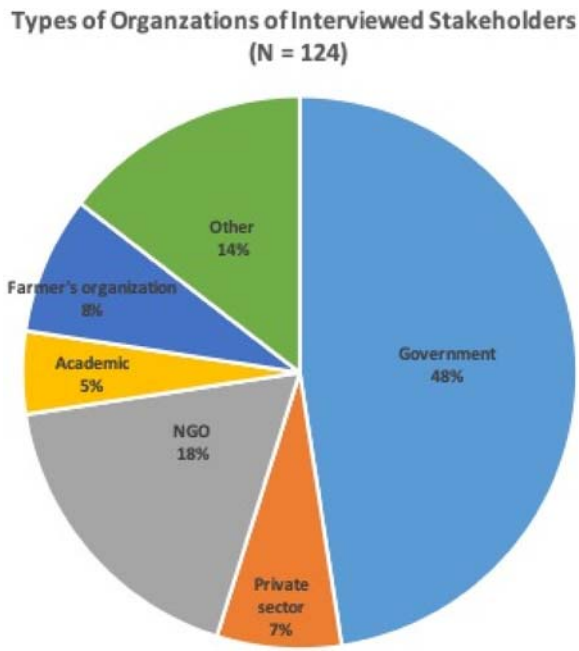

Figure 3. Types of organizations engaged in the baseline stakeholder survey in Ethiopia, Tanzania, and Zambia ($n = 124$).

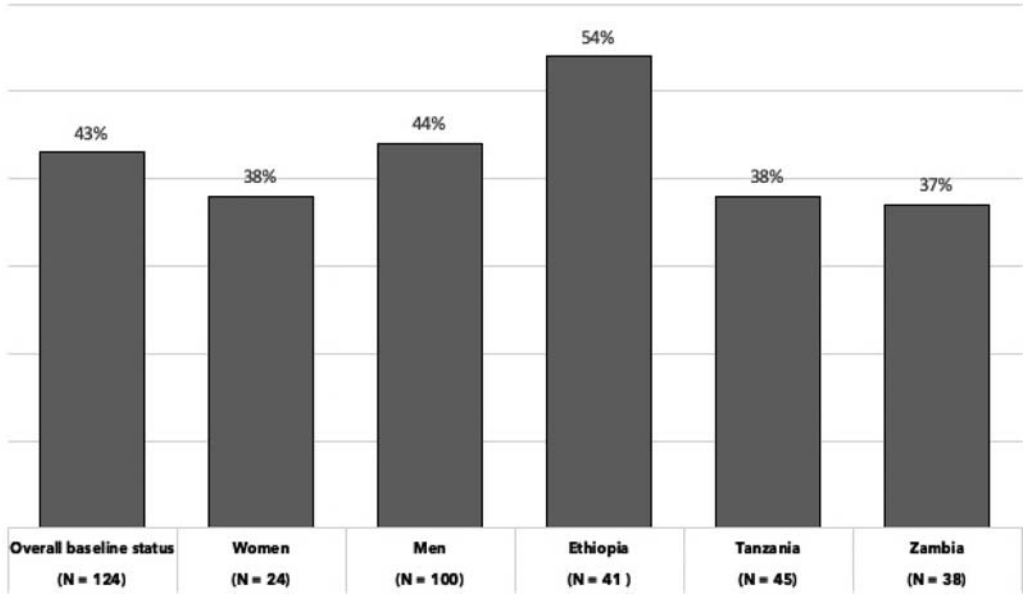

Figure 4. Intermediary Outcome 1, Indicator 2: % of targeted stakeholders with demonstrable ability to access, appraise, and use available evidence on SAI relevant policies, mechanisms and interventions.

Stakeholder analysis

The stakeholder analysis using social network mapping was undertaken at sub-national and national levels. The density of the network shows how connected the actors in the network are with a maximum possible value of one if all actors are connected. None of the networks were highly connected and hence density values are low in general. The district-level network in Solwezi, Zambia had the greatest density of 0.034, out of a possible 1, compared to the other networks (Table 1). Overall, these data

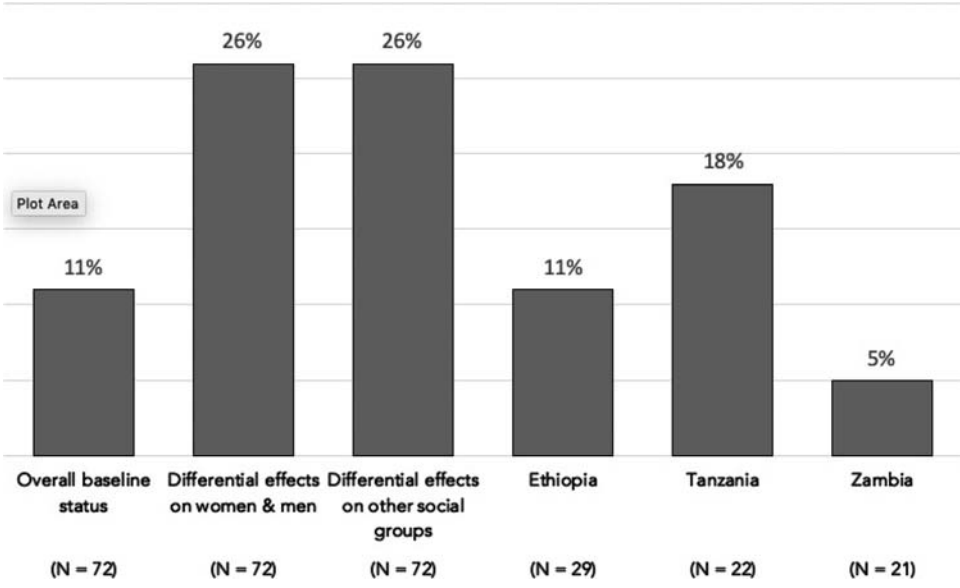

Figure 5. Percent of targeted high-level decision makers and investors reporting that their organizations are incorporating evidence on differential effects of SAI policies and interventions on women and other groups.

Table 1. Results from the social network analysis (SNA): Network features for the local and national level SAI networks for Tanzania, Ethiopia and Zambia.

Network	Actors interviewed	Actors in network (nodes)	Connections (ties) between all actors	Density of network
Mbarali District, Tanzania	27	97	104	0.011
Tanzania National	14	63	73	0.019
Ziway District, Ethiopia	15	73	81	0.015
Ethiopia National	20	40	46	0.029
Solwezi District, Zambia	17	41	59	0.034
Zambia National	11	53	62	0.022

demonstrate the unconnected nature of the networks and the potential to enhance collaboration in terms of information exchange, particularly around SAI tradeoffs and information.

The national level stakeholder networks for SAI information exchange were captured for Tanzania, Zambia and Ethiopia and are presented as sociograms. Government, NGOs and research organizations had the highest degree of connectivity in that they had the highest number of connections to other actors. The degree of connectivity indicates the extent to which actors share or access information with other actors and those with a large set of connections in the network are likely to be more powerful or influential given their higher access to information.

The stakeholder network captured for Tanzania at the national level, with some interviews of regional actors, showed that government actors, in this case the Ministry of Agriculture, Livestock and Fisheries (MALF), was more connected than other actors (Figure 6). This reflects the centralized nature of information exchange in Tanzania. Other actors with relatively high degrees of connectivity included the NGO Care International, the Tanzania Forest Conservation Group and the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). The network in Figure 6 also shows that there are many opportunities to enhance or build connections, particularly between research, public-private partnerships and NGOs.

The National SAI Stakeholder Network for Zambia included a large number of research organizations that were often linked to NGOs and intergovernmental organizations such as FAO or regional networks such as AGRA (Figure 7). Identification and connectivity with government ministries illustrated a gap in the network and was identified as an area for further intervention for the project. The Interim Climate Change secretariat and the Zambian Agricultural Research Institute (ZARI) were the most connected stakeholders overall. Stakeholders that were not interviewed but were mentioned a number of times included the World Bank and FAO.

The national stakeholder network captured as a baseline for Ethiopia included a large number of research institutes, donors, NGOs and some government departments (Figure 8), but with a limited degree of connectivity. For evidence-informed decision making, the connection between researchers and implementers/donors is encouraging and was identified as an area that could be strengthened through SAIRLA. The Ministry of Agriculture, Natural Resources department was the most important stakeholder linking the network and had the highest number of connections.

Participatory tradeoff activity

The participatory tradeoff activity was conducted with partners in all three countries (Ethiopia, Nov 2019 $n = 24$ participants; Tanzania in August 2019, $n = 23$ participants and in Zambia in September 2018, $n = 47$ participants. Participants assessed the influence of selected SAI practices on the five dimensions (Agricultural Productivity, Income, Land Health, Human Condition, Social Aspects). This activity was carried out for at least four SAI practices in each country, e.g. integrated soil fertility management, conservation agriculture, intercropping, agroforestry, among others. Figure 9 shows the radar graph generated by the five groups: (1) Government; (2) Private sector; (3) NGOs; and (4) Research Institutions) during the national level workshop in Ethiopia, note the variation in perceptions. An interesting outcome was the differing views of the tradeoffs from the different stakeholder groups, for example there was not strong agreement on the impact of homegarden agroforestry on human condition nor social aspects, while a majority of the stakeholders agreed on the positive contribution of homegardens to household income. This highlights the need for cross-sectoral engagement with evidence to discuss and debate these tradeoffs for decision making.

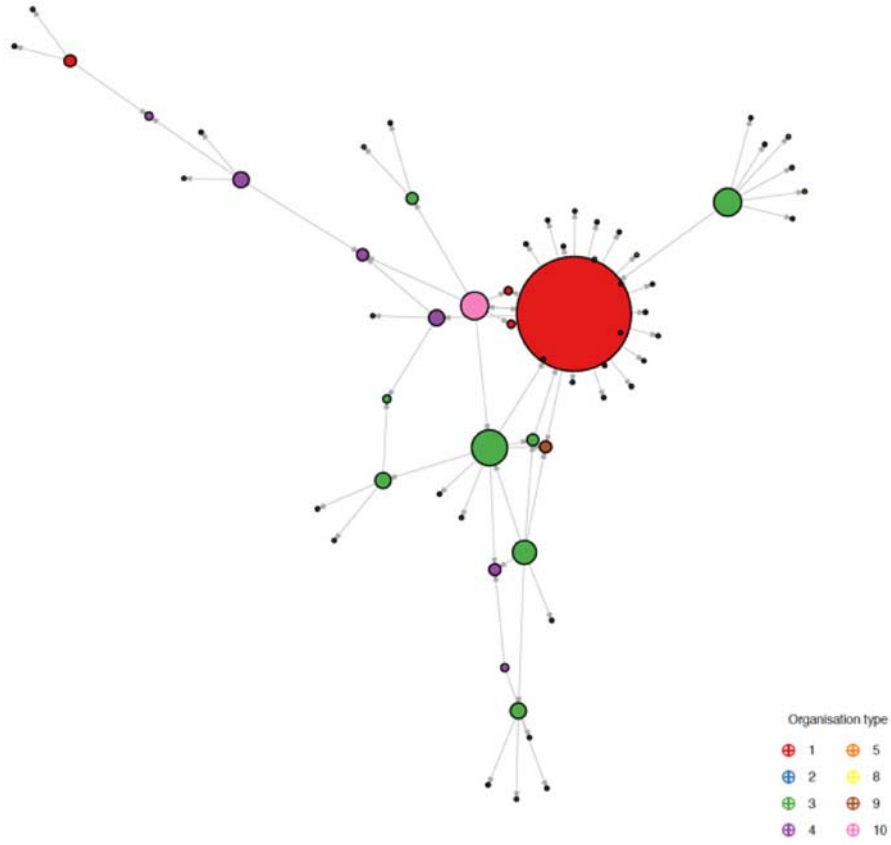

Figure 6. Tanzania, National and Regional SAI Stakeholder Network, showing actors with most connections as larger circles (red (1) = government, green (3) = NGO, purple (4) = research, orange (5) = farmer organizations and unions, yellow (8) = other, brown (9) = intergovernmental and pink (10) = public-private).

Another key aspect of the activity was to identify data needs in order to make more informed decisions. For example. at the national level in Ethiopia, stakeholders concluded that sufficient evidence was not available for all of the five dimensions of SAI evaluation, and highlighted the need for this information all in one location. Furthermore, the workshop focused on the investments needed to overcome these tradeoffs and the factors hindering the investments. Table 2 provides the specific feedback from each group during the Solwezi workshops. Key insights include the needed for controlled grazing to improve soil and land health, the need for available tree seedlings for establishing agroforestry practices, demonstration and communication of the evidence on the performance of the various practices.

Finally, another key observation from the participatory tradeoff activity was the need for both capacity building in developing and interpreting graphs, including radar graphs which are generally used to describe the influence of a particular SAI technologies on the multiple dimensions. This has implications, in general for barriers to the use of evidence in decision making.

SAI decision dashboards

A key element of SAI in the context of SAIRLA lies in understanding how various stakeholders obtain and share information, and how this information is used in prioritizing SAI practices that minimize potential negative impacts of agricultural intensification on the environment. During the project stakeholders repeatedly expressed need for data and information at their fingertips to aid in decision making and prioritization. The SAI dashboards were co-developed with stakeholders to allow various groups of stakeholders, to visualize and assess: (1) root-causes of important

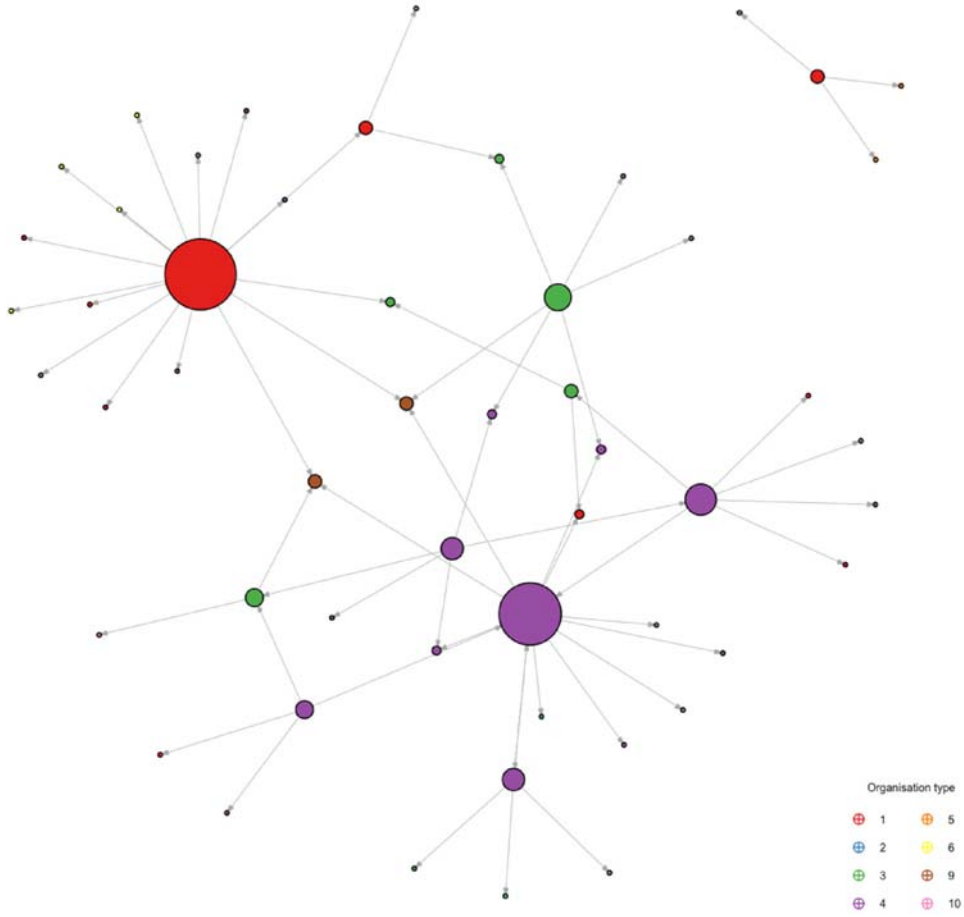

Figure 7. Zambia National SAI Stakeholder Network Baseline, showing actors with most connections as larger circles (red = government, green = NGO, purple = research, brown = intergovernmental).

constraints (barriers) to SAI adoption; (2) stakeholder networks and their connectivity to inform upscaling activities; (3) prioritization of SAI practices by women and men; (4) multidisciplinary tradeoffs; (5) agricultural yield under various management practices; and (6) socio-economic data. In addition, the dashboard visualizes maps of land health indicators such as soil erosion prevalence and soil organic carbon as well as climate trends. These data aided to better understand and identify biophysical constraints facing agricultural productioon and serve as a platform to facilitate communication of data and analysis between scientists and stakeholders, including national and international learning alliances. In Tanzania, the Mbarali district collated and uploaded additional datasets including irrigation scheme data, as well as agricultural production data for several crops over time. In addition, the homepage and navigation bar have been translated into Kiswahili. For the district of Mbarali, the dashboard is also available through the district's website (https://www.mbaralidc.go.tz/dashboadlinks). Figure 10 shows the screenshot of the Tanzania Dashboard homepage and the 10 modules (Socio-economic; Root cause analysis; Stakeholder mapping; Prioritization of SAI practices; SAI trials; Tradeoffs; Land health; Crop production and storage; Climate; and Irrigation).

All three country dashboards are available online:

- https://landscapeportal.org/SairlaTanzania/
- https://landscapeportal.org/SairlaZambia/
- https://landscapeportal.org/SairlaEthiopia/

To further facilitate the sharing of data and evidence, information from each module can be downloaded as a pdf and the data can be downloaded as

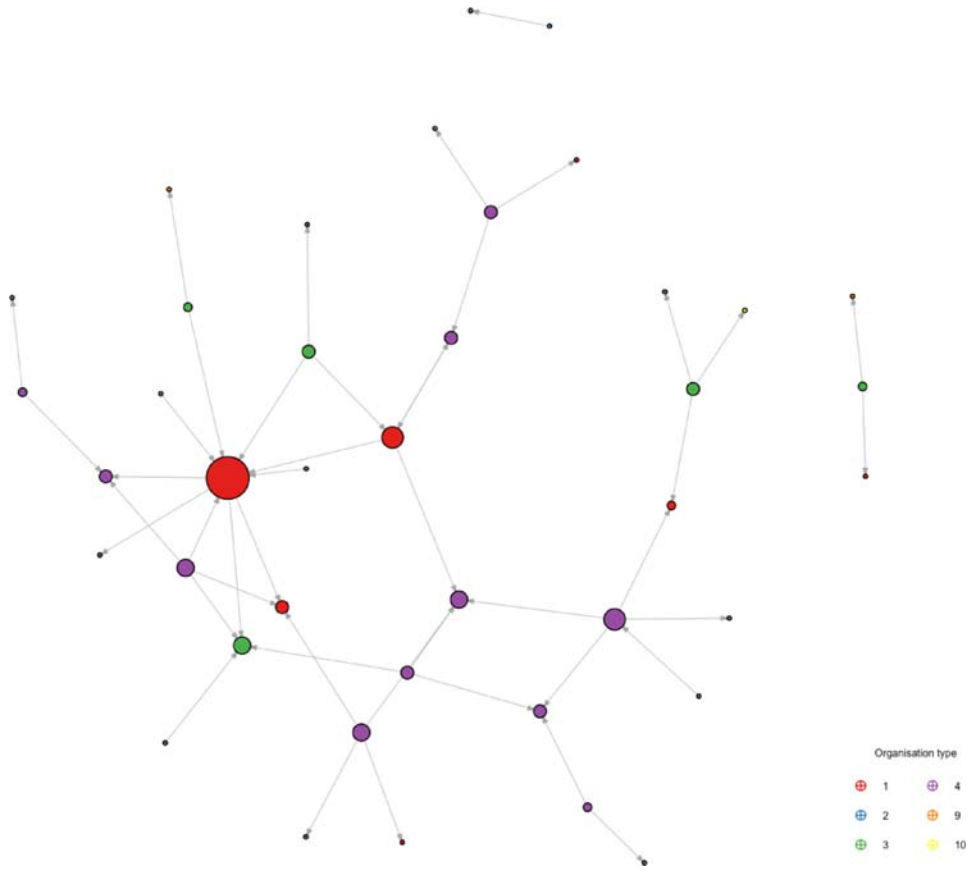

Figure 8. Ethiopia National SAI Stakeholder Network, showing actors with most connections as larger circles (red = government, green = NGO, purple = research).

a comma-separated (csv) file, which can be opened in all common spreadsheet software. Users can also download a user guide and a facilitation guide for champions building capacity on the use of the dashboard.. Each dashboard also has responsive themes to work on various devices, including smartphones and are optimized for low internet connection speeds.

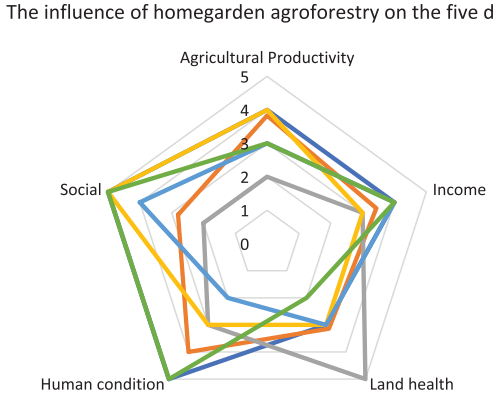

Figure 9. Results of the scoring exercise on the influence of homegarden agroforestry on the five dimensions of SAI evaluation, each colour represents the results from the five different groups (1) Government; (2) Private sector; (3) NGOs; and (4) Research Institutions) during the Ethiopia workshop.

Table 2. Example feedback on investments need to minimize tradeoffs, from Zambia participants.

Group	*Theme that needs attention*	*Indicators that need change*	*Investments to minimize tradeoff/negative impacts*	*Factors hindering investments*
Solwezi group 1	Land health	Vegetation cover	• Afforestation • Controlled grazing/growing pasture/ paddock • Protect water bodies (digging canals) • Promotion of conservation farming practices • Capacity building for extension officers and farmers in good agricultural practices • Avoid burning crop residues • Invest in fire guards	• In adequate extension officers • Inadequate finances and mode of transport • Cultural differences/attitude • Communication on importance of fire guards through village headmen, group leaders, Chiefs etc. • Evidence to show the performance of these techniques
Solwezi group 2	Income	Labour requirement	• Access to credit to buy machinery • Increased income • Increased hectarage under cultivation • Reduced time to work hence allowing farmers to work on other practices	• High bank interest rates • Lack of collateral
St Francis group 1	Social	Access to credit	• Land titles • Bank to reduce rates • Banks to give loans without collateral • Machined farming • Commercial farming • Irrigation	• Lack of capital • Dependence on rainfed agriculture • High cost of equipment • High interest rates • Diversification into other forms of farming
NLA group 3	Human conditions	Nutrition Human health	• Investment in multipurpose trees that supports environmental restoration but also bears nutritional fruits that smallholder farmers can consume • Invest in other land restoration crops e.g. legumes that can be planted alongside the main cereal crops	• Funding structures from financial institutions • Land tenure mechanisms that currently exist do not allow this kind of environment
Mutanda Group 1	Social	Participation of marginalized groups	• Encourage marginalized groups to join clubs or cooperatives for them to benefit	• Promote the SAI practice through demonstration sites and information through traditional leaders
Mutanda group 2	N/A	N/A	• Increased demonstration of importance / benefits of minimum tillage • Evidence on the performance of practices	• Lack of government commitment to promote the practice • Lack of information/evidence about the benefits of the practice
Mutanda group 4	N/A	N/A	• Sensitize communities about the importance of agroforestry, especially during field days • Government and NGOs to increase access or availability of seedlings for agroforestsry trees	• Inadequate sensitization about the benefits of agroforestry • Lack of access/unavailability of seedlings of agroforestry trees • Unavailability of animals such as cattle goat and sheep

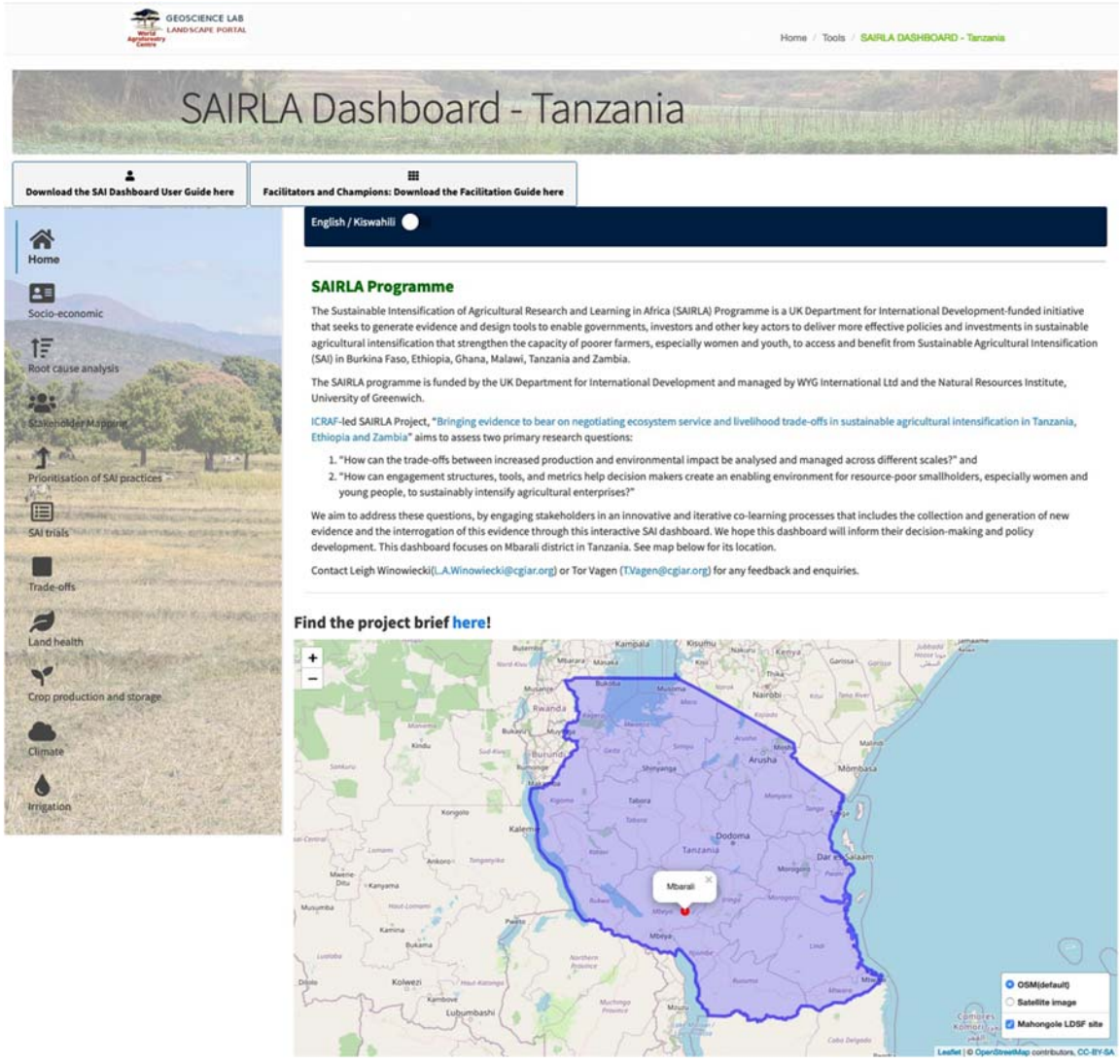

Figure 10. Screenshot of Tanzania SAI Dashboard homepage.

SAI dashboards feedback and use

Using Google Analytics, we tracked the number of unique users, number of unique sessions and the number of countries from which the visitors accessed the dashboard over a period of 7.5 months (between 1 March 2019 and 17 October 2019). Tanzania had the highest number of unique sessions ($n = 206$), followed by Ethiopia ($n = 149$) and Zambia ($n = 96$). The number of unique users in Tanzania was 104, compared to 71 in Ethiopia and 66 in Zambia. These data demonstrate the dashboard was being accessed during this time period.

Specific feedback on the ideal users of the dashboard as well as the specific decisions the evidence provided in the dashboard could inform were also tallied. Some of the suggestions on the types of decisions the dashboard could be used for are listed below:

- As a planning instrument to evaluate and monitor effectiveness and sustainability – Ethiopia
- For planning and evaluation, policy formulation – Ethiopia
- Policy decisions: project implementation benchmarks for places where projects can be sited – Zambia

Figure 11. Word cloud of the phrases used by stakeholders to describe the uses of the decision dashboard.

- In the development of the next National Agriculture Implementation Plan (NAIP); in formulating agriculture policy; in the monitoring and evaluation of agri-implemented projects by the government and NGOs – Zambia
- Land use management; policy makers especially when it comes to decisions on land use allocation given different land utilization types versus environmental conditions (existing) – Tanzania
- Policies on input usage in specific areas – fertilizers and seeds; farmers to decide on which products should be produced where – Tanzania
- The dashboard development team has been responsive to the feedback as it comes in.

Stakeholders suggested the following as some of the decisions that can be informed by the SAI dashboards (Figure 11):

- Development of the next National Agriculture Implementation Plan (NAIP) in Zambia
- Monitoring and evaluation of agricultural projects implemented by the government and NGOs as well assisting future planning
- Critical areas which require interventions to improve livelihood of farmers and improve networking among stakeholders
- Project implementation benchmarks for places where the projects can be sited
- Land use planning and management especially decisions on land use allocation given different land utilization types versus existing environmental conditions
- Policies on input usage
- Tradeoffs between forest management and sustainable agriculture productivity
- Tradeoffs between food environment, food security and tree productivity
- Policies on environmental conservation
- Types of crops to be grown according to the land health and climate. When and where to be grown. What to produce, when to produce, what inputs are lacking, who is going to be involved and available.
- Planning, monitoring, evaluation, policy formulation, research, project appraisal, strategic planning
- Monitoring and evaluation of the agriculture act in Tanzania
- Design of advocacy interventions

Changes made on the dashboard because of the feedback received

Responses to the question 'Who is the dashboard useful for?' included: (1) Any organizations active in SAI; (2) NGOs; (3) Government; (4) Smallholder farmers; (5) Policy and decision makers; (6) Researcher; and (7) Technical staff (extension officers, project coordinators/officers).

In addition to the dashboard feedback forms, the final afternoon sessions of the workshops were conducted in plenary to ask participants specific actions needed to increase the use and sustainability of the SAI dashboards. Suggestions were made around increasing the visibility and awareness of the dashboard, identifying key champions at various institutions, making an offline version of the dashboard, including additional sources of data, and including the link of the dashboard on the website of the respective Ministry of Agriculture. It was agreed in each country, that the various NLAs have a key role to play in increasing the awareness of the dashboard by targeting the awareness and publicity to the relevant thematic groups within the NLA such as the Sustainable Land Management group or Tradeoffs group.

Discussion

Multi-stakeholder engagement and cross sectoral coordination

Using the SHARED approach, the intentional use of a suite of structured stakeholder engagement activities at local and national levels identified key entry points for the scaling of SAI. This included the importance of linking stakeholders across the administrative levels and across sectors as a basis for a more coherent approach to SAI. Specifically in terms of prioritizing contextually appropriate and effective interventions, linking existing SAI related projects and policy support, understanding information needs, and identifying evidence accessibility to support best practices and priority investments for scaling SAI.

Our focus was the identification of stakeholders to be engaged in the study and to see where further efforts are needed to bring disconnected stakeholders into the network, rather than identify the typology of each stakeholder. We used social network analysis to identify the role and influence of the individual stakeholders based on their position in the network as applied in other studies (Prell et al., 2009; Wassermam & Faust, 1994). Initial stakeholder analysis revealed that the SAI networks were largely disconnected with a few key stakeholders providing central and linking roles. Similar results have been found, even within multi-stakeholder platforms in the region (Hermans et al., 2017). Some variation was seen between the three countries, for example in Tanzania one organization was dominant while in Zambia and Ethiopia a number of stakeholders loosely connected the network. This suggests that diverse engagement processes are needed to bring more stakeholders into connected roles in the networks to ensure information flow and exchange of ideas amongst the organizations.

Given this interdisciplinary nature of SAI, the disconnected nature of the SAI networks provides an opportunity to bring together a range of stakeholders to shape the scaling process, as we attempted in this study. However, further and continuous engagements will be needed in the future.

The combination of the methods and processes utilized in this study, using the SHARED approach, served as a mechanism for prioritizing and scaling SAI practices and enhancing knowledge exchange and evidence based decision making and investments at the local and national level. In Ethiopia, Tanzania and Zambia, we demonstrated the value of multi-stakeholder and cross-sectoral engagement and the input of high quality, country relevant evidence to support the uptake of cost effective and contextually appropriate SAI interventions by women and men farmers and to inform local and national decision making and investments in support of scaling SAI nationally.

Evidence access and use

Access to and use of evidence for SAI decision making was found to be limited in this study, particularly with respect to more nuanced evidence related to gender and social groups.

While each of the stakeholder groups across scales interviewed reported that they used some information and evidence in their decision making, the sources of information and evidence tended to be from workshops, country specific research reports, the internet and brochures. When the project probed to determine which kinds of data characterizing data for SAI interventions were available to support decisions on SAI implementation and investment, it was found that available data in both an accessible location and format and data gaps are a serious challenge. Stakeholder engagement with evidence and the co-design of the decision dashboards created enthusiasm for collating, sharing and uploading evidence. By applying advanced data visualization and actionable data, the SAI dashboard helped facilitate communication of data and analysis between scientists and stakeholders. This allowed for interrogation of evidence and increase the rate of discovery and help contextualize the data used. However, long-term capacity development efforts are needed for various stakeholders in terms of data collection, curation and interpretation. Creating a culture of evidence use and inclusive decision making takes time. Continuous and regular engagement is critical for the co-design process and ultimate utility and sustainability of the dashboards as well as for the influencing of SAI policy development and implementation.

One of the lessons learned is that the importance of capacity development for decision-makers to interpret and incorporate evidence into decision making. A positive outcome of this project has been the capacity development in this area. Data visualization has been acknowledged as a powerful way to support synthesis, communication and use of data. Visualized data is more attractive, sharable as well as easy and fast to understand. Through engaging people to interact with data it inspires curiosity and prompts discussion

around interpretation and application. The use and discussion starts to create a culture of data. By presenting available information on SAI in a place that is easy to access and share, that is visually appealing and interactive, people are more likely to access and use the data. Furthermore, this engagement with data is more likely to create a culture for additional data collection and analysis and contribute to enhancing the information available through finding or sharing additional data sets.

Participatory tradeoff analyses

Perceptions of the various tradeoffs differed by stakeholder groups and provides an important starting point for discussing and deciding what SAI practices to promote, where and for who. In all countries, while the term 'trade off analysis' is often used, the concept of tradeoff analyses around SAI were not immediately understood. An interesting finding in this study was the diversity of responses received in relation to trade-offs. Where evidence was available it was interpreted in diverse ways as seen in the five different trade-off scores developed during the stakeholder workshops. This demonstrates that participatory tradeoff analysis produces 'clumsy solutions' as described in Frame and Brown (2008), where diverse stakeholders are engaged for the co-production of sustainability know-how and there is a plurality of legitimate perspectives. Participatory tradeoff exercises are essential but are unlikely to produce one concrete answer. While the discussion, contextualization and diverse interests are essential, a follow-on negotiated dialogue would be needed to take this exercise to the planning stage. It was important to bring together different stakeholders at local and national levels to collectively raise awareness and build capacity on how to carry out participatory tradeoff analyses including the evidence required.

Key lessons learned categorized by stakeholder group

Scaling SAI requires the combination of farmer interest, capacity, adoption and benefits in conjunction with enabling policy and institutional relationships in support. In addition to agricultural ministries, there are other relevant sectors that must be engaged and coordinated, such as environment, lands, education, health, and finance among others, particularly to ensure that underpinning causes of the barriers to adoption are addressed. Multi-level approaches were viewed as critical to scaling up SAI including (a) enhancing coordination across initiatives and institutions; (b) raising awareness and capacity development locally and nationally; (c) on farm interventions and demonstration plots, local level exchange visits (including dialogue and exposure for national level actors) and trainings; (d) national level practice and policy dialogues. Below are a few key lessons learned from the various stakeholder groups.

Researchers and development actors

(1) Evidence generation and sharing needs to fit within the decision making cycles of various stakeholders, including farmers, decision makers and investors.
(2) Flexibility is needed when co-developing decision support tools, including decision dashboards to ensure their utility and sustainability.
(3) Continuous engagement is needed.
(4) Responsive capacity development events need to be tailored to meet the needs of the stakeholder groups.

Policy makers

(1) The National Learning Alliances (NLA) were key champions for the dashboard and provide a platform for continued co-development of the dashboards in each country. The continuation of such a platform will be essential to link policy makers and research / development actors to enhance knowledge exchange.
(2) Early engagement of decision makers in the co-design of the decision dashboards was critical for use, dissemination and promotion.
(3) It was stated that while researchers are often consulted during the decision making process at the National level, the feedback process could be strengthened.
(4) Enhance capacity for data collection, data storage and data interpretation, including on the concept of tradeoffs for decision making is needed.

Farmers

(1) Co-learning across countries could be useful to share lessons on what is working, where, in terms of scaling mechanisms for SAI.

(2) Exposure to diverse farming systems is needed to allow farmers to tailor and adapt farming practices to meet their needs.
(3) Experience from the SHARED national workshop needs to shared back to the communities.
(4) Enhanced collaboration in data collection efforts may encourage discussions on the performance of various SAI practices on the multiple dimensions.

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Appendix 1: Baseline survey questionnaire.

1. What is your full name?	
2. Gender	Female Male
3. What is your contact number?	
4. Do you have an email address? If yes, what is your email address?	
5. What is the name of the main organization you work for or represent?	
6. What type of organization is this?	Government Private sector (profit) NGO (Non Governmental Organization) Academic or research organization Farmer's organization/union Community based Organization (CBO) Media Other (specify) _____
7. What your main role (position) in this organization or body?	Director/Chair/Leader Board Member Unit Head/Manager Program/Project/Extension Officer Other (specify) _____
8. In what particular ways is sustainable agricultural intensification – defined as intensifying agricultural production without negative environmental impacts – relevant to the work your organization does? *(select all that apply)*	We are involved in developing country-level agricultural policies We are involved in designing specific agricultural programmes and projects We are involved in managing or implementing agricultural programmes and projects We provide agricultural extension support directly to farmers We carry out research on agriculture Other (specify) _____
9. To what extent does your organization develop government agricultural policy that may be relevant to SAI?	To a large extent To a medium extent To a small extent Not at all
10. To what extent does your organization make decisions on how resources (financial and human) are allocated to the agricultural sector?	To a large extent To a medium extent To a small extent Not at all
11. To what extent is your organization involved in the development and design of agricultural programmes, projects, and interventions?	To a large extent To a medium extent To a small extent Not at all
12. To what extent is your organization involved in disseminating information on improved agricultural methods?	To a large extent To a medium extent To a small extent Not at all
13. Over the past 12 months – that is, since September of last year – have you either read, participated in a workshop or training, or accessed information from another source on how to intensify agricultural production without harming the environment?	Yes No *(many of the stakeholders at local level may say no here, in which case move to question 23 and then go to projects and then the stakeholder network survey)*
14. What type of information were you able to access in particular? *(select all that apply)*	General background information on SAI Information on specific SAI practices relevant for specific areas of your country Evidence on the effectiveness of one or more specific SAI interventions, such as that generated from an impact study Other (specify)_____
15. What was the source of this information on SAI? *(select all that apply)*	Brochure/pamphlet on SAI General (non-research) report on SAI specifically Research report or paper on SAI Training session or workshop on SAI Internet information on SAI Online video or television program SAIRLA Dashboard Other (specify) _____

16. Did this information specifically discuss or present how the SAI interventions in question affect men and women differently?	Yes No
If yes How in particular did this information describe how the SAI intervention(s) affects men and women differently? *(select all that apply)*	General description on how SAI may potentially affect men and women differently Findings from a qualitative case study on how SAI affects men and women differently Disaggregated quantitative data on how SAI affects men and women differently Other (specify) _____
17. Did this information describe how the SAI interventions in question affect other specific social groups differently, such as rich versus poor farmers or farmers in one particular geographical area versus another?	Yes No
If yes How in particular did this information discuss or present how the SAI intervention(s) affected these other social groups of farmers differently? *(select all that apply)*	General description on how SAI may potentially affect different groups of farmers differently Findings from a qualitative case study on how SAI affects different groups of farmers differently Disaggregated quantitative data on how SAI affects different groups of farmers differently Other (specify) _____
18. To what extent did you find this information on SAI trustworthy and reliable (that is, credible)?	To a large extent To a medium extent To a small extent Not at all
19. To what extent did you find this information relevant and applicable to the work of your organization?	To a large extent To a medium extent To a small extent Not at all
20. Has your organization incorporated any of this information on SAI into its work over the last 12 months, that is, since September of last year?	Yes No
If yes In what particular ways did your organization do this? *(select all that apply)*	It was used in the design of government/ organizational policy and/or strategy on agriculture It was used in the design of one or more specific programmes or projects It was used in the design of one or more specific interventions under an existing programme or project It was used to inform the training of or direct extension given to farmers It was used to inform design of extension materials to be delivered to farmers Other (specify) _____
21. Has any of the information/evidence on how SAI affects men or women differently been factored into your oganization's work over the past 12 months?	Yes No
If yes In what particular ways did your organization do this? *(select all that apply)*	It was used in the design of government/ organizational policy and/or strategy on agriculture It was used in the design of one or more specific programmes or projects It was used in the design of one or more specific interventions under an existing programme or project It was used to inform the training of or direct extension given to farmers It was used to inform design of extension materials to be delivered to farmers Other (specify) _____
22. Has any of the information/evidence on how SAI affects particular groups of farmers (other than men and women) differently been factored into your organization's work over the past 12 months?	Yes No
If yes In what particular ways did your organization do this? *(select all that apply)*	It was used in the design of government/ organizational policy and/or strategy on agriculture It was used in the design of one or more specific programmes or projects It was used in the design of one or more specific interventions under an existing programme or project It was used to inform the training of or direct extension given to farmers It was used to inform design of extension materials to be delivered to farmers Other (specify) _____