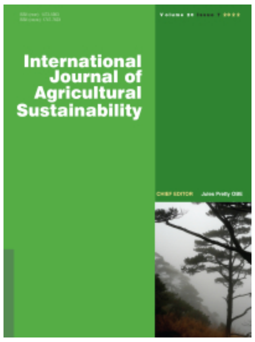

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Evaluation of the dairy sustainability assessment tool (DSAT) for dairy systems in East Africa

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ABSTRACT

Sustainability assessment of dairy systems is necessary to understand bottlenecks and to identify measures to enhance sustainability of the systems. The Dairy Sustainability Assessment Tool (DSAT) was developed with a focus on the facilitation of discussion on sustainability among dairy sector actors in East Africa. DSAT has been applied in several case studies, but the tool has not been systematically evaluated. The objectives of this study were to evaluate the strengths and weaknesses of DSAT and to compare its main features with similar dairy assessment tools for Africa. This evaluation consisted of a literature search to identify relevant assessment tools and an online survey about the tool among its users. DSAT was different from other tools compared with as it does not require input data from farm surveys as the assessments rely on expert opinion, and it can conduct assessments at farm, regional and national scales. Results also showed that DSAT was appropriate for holistic assessments of the sustainability of dairy systems in Africa by providing a good overview of threats to sustainability. Weaknesses were mainly the scoring of indicators, which tends to be subjective and the absence of numerical reference values for indicators. Therefore, improving DSAT requires addressing the identified weaknesses.

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Sustainable intensification; sustainability aspects; farming systems; smallholder farmers; model evaluation

1. Introduction

Dairy production is an integral part of livestock systems in East Africa. It is characterized by varied systems of production from large-scale (often commercialized) to smallholder systems, though the latter is dominant (Ashagrie et al., 2023; van der Lee et al., 2016). For example in Kenya, van der Lee et al. (2016) reported that smallholder milk-producing households who own one to three cows, on aggregate account for over 80% of the national dairy herd. Dairy production provides economic opportunities for millions of smallholder farmers in Africa (Udo et al., 2011). The rapidly growing demand for animal-source foods, including dairy products, in East Africa has led to increased smallholder dairy production, particularly in peri-urban areas to take advantage of the available market (Migose, 2020; Paul, 2019; Staal et al., 2008). Associated with this increased production are issues regarding forage production and conservation, animal health and welfare, manure management, greenhouse gas emissions, farm economic returns and dairy product safety. All these issues raise concerns about the sustainability of dairy systems in East Africa.

The sustainability of a dairy system, as in any other farming system, has three dimensions, namely

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environmental, economic and social (Ayantunde et al., 2018; González Esquivel, 1998; Maleko et al., 2018; Paul et al., 2020). From an environmental point of view, sustainability implies the preservation of non-renewable resources, the appropriate use of renewable ones and a reduction in the current levels of pollution. In economic terms, sustainability focuses on the efficient use and maintenance of both the natural and the man-made resource base and the provision of appropriate returns to the farm households (González Esquivel, 1998). The social dimension of sustainability is concerned with enhancing social organization, equity, the culture of rural life and maintaining food security. Therefore, an integral assessment of the sustainability of the dairy systems in Africa is vital for understanding the strengths and weaknesses associated with resource use within these systems to increase food production in a sustainable way (Atanga et al., 2013).

Sustainability assessment of farming systems, in this case, dairy systems, is necessary to understand its sustainability in terms of environmental, social and economic dimensions, to identify measures that may be necessary to enhance the sustainability of the systems and to engage with different stakeholders including policy-makers on the implementation of the identified measures. To this end, different sustainability assessment tools have been developed with varied objectives. Chopin et al. (2021) conducted a review of 119 farm sustainability assessment tools and De Olde et al. (2016) provided a list of 48 tools for the assessment of the sustainability of farming systems at farm scale. Both studies demonstrate that lots of tools are available for farm sustainability assessments although most of them may not be useful for dairy systems in Africa. Examples of farm sustainability assessment tools are RISE (Response Induced Sustainability Evaluation; Hani et al., 2003), IDEA ('Indicateurs de Durabilité des Exploitations Agricoles' or Farm Sustainability Indicators; Zahm et al., 2008), SAFA (Sustainability Assessment of Food and Agriculture systems; FAO, 2013), MOTIFS (Monitoring Tool for Integrated Farm Sustainability; Meul et al., 2008) and the PG-Tool (Public Goods Tool; Gerrard et al., 2012). Generally, the objectives of these tools are to simplify and describe a complex system and to gain insight into the sustainability performance of the system at different scales. The tools may also be used to guide discussions on the sustainability status of a system and inform decision-making in developing action plans to enhance the systems' sustainability performance. Sustainability assessment tools tend to differ in focus on sustainability dimensions, scale (farm, regional, national or sectoral), input data requirements, time to conduct an assessment, presentation of outputs and intended end-users (De Olde et al., 2017; van Passel & Meul, 2012). In general, these are all tools in which a set of indicators relating to the environmental, economic and social dimensions are used to assess the sustainability performance of a given system.

The Dairy Sustainability Assessment Tool (DSAT) was developed by Wageningen Livestock Research with similar objectives as other sustainability assessment tools mentioned above but with a focus on the facilitation of discussion among dairy sector actors in East Africa (Ndambi et al., 2020). Besides, the DSAT was specifically developed for the African dairy farming context, unlike most other tools which were originally developed for farming systems in the global North though they may also be applied in low- and middle-income country contexts. Stakeholder involvement in creation and development could improve the adoption of sustainability assessment tools and is essential to ensure that the tools fit their end-user base (Whitehead et al., 2020). Therefore, stakeholders from research institutes, development organizations particularly non-governmental organizations working on dairy, veterinary and extension services, government dairy regulatory agencies and some dairy value chain actors (for example farmers, dairy cooperative representatives, processors, and transporters) were consulted. After its development, DSAT has been applied in several case studies in East Africa from 2022 onwards, but the tool has not been systematically evaluated and compared to other sustainability assessment tools to date. However, evaluation of the tool with end users is required to see whether the tool meets their demands and to identify areas for improvement. Therefore, the objectives of this study were to evaluate the strengths and weaknesses of DSAT based on the perceptions of its users and to compare its main features with similar dairy assessment tools that are applicable to Africa, based on a common framework. This evaluation will help in improving DSAT and may provide useful information for similar dairy sustainability assessment tools that are applicable to Africa, in terms of potential areas for improvement. This study adds to the literature on the evaluation of tools, whereas most of the literature on this topic just describes the tools or applications of tools to case studies.

2. Materials and methods

2.1. Description of DSAT

The DSAT was developed to facilitate and guide discussions among farmers, cooperatives, companies and other stakeholders on sustainability of the dairy production in East Africa with potential wider application in other regions of Africa (van der Lee et al., 2022). The development of DSAT was based on a request by the Netherlands Food Partnership (NFP) dairy action agenda together with the Netherlands East Africa Dairy Partnership (NEADAP) initiative for a tool that enables stakeholders to assess and monitor the sustainability of dairy initiatives in East Africa. The discussions with stakeholders revolve around identifying the boundaries of the dairy system being assessed, be it at the farm, milkshed or country level; the main threats to sustainability; assessing the current performance of the selected system based on sustainability aspects (criteria), using relevant indicators and identifying critical areas for further elaboration on pathways and actions to enhance sustainability (van der Lee et al., 2022). Outputs from DSAT are expected to guide and inform dialogue and or the action planning process.

The process for the development of DSAT started with a study to assess 42 sustainability assessment tools that have been developed and used in different low- and middle-income countries to monitor the environmental, economic and social dimensions of dairy farming (Ndambi et al., 2020) from which four tools were selected to be of potential use to guide the design of DSAT but two were eventually used as most suitable, namely RISE and SAFA, based on ease of adaptation to East African context, data requirements, simplicity, user-friendliness and reliability of results (Ndambi et al., 2020). Sustainability aspects and indicators used in these two tools were used as a starting point and augmented with additional indicators from literature. In developing DSAT, necessary adjustments were made by removing less relevant indicators and adding new ones with the stakeholders and modifications were made to the formulation of indicators to make them easier to understand. These modifications were deemed necessary to ensure that the indicators used match the characteristics and realities of the dairy system in East Africa. The version of DSAT tested was an Excel-based tool which is available on request. The tool follows the structure of (i) dimension, (ii) theme (referred to as aspect in DSAT) and (iii) indicators. The details on DSAT, description of the aspects and indicators, and how to use it are described in the DSAT User Manual (van der Lee et al., 2022). The steps in using DSAT consist in (i) deciding the level of assessment (that is, scale) and system boundaries, (ii) selecting scoring approach (individual or group), (iii) selecting sustainability aspects for the assessment, (iv) scoring the indicators for each selected aspect and (v) discussing the results as presented in a radar graph (Figure 1). The DSAT tool distinguishes 14 sustainability aspects (themes), with each aspect being assessed with between 2 and 5 indicators (Appendix). Since the evaluation of DSAT described in this paper, the Excel version of DSAT has been replaced by a web version (www.lsat-online.com).

The scoring of the indicators is based on four levels, ranging from low/poor (score = 1; red colour) via orange/yellow to high/good (score = 4;

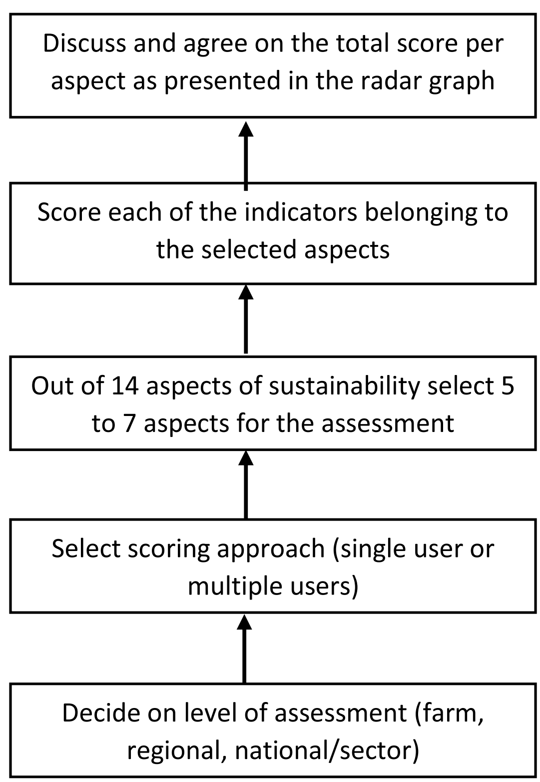

Figure 1. Steps in the sustainability assessment of dairy systems using DSAT.

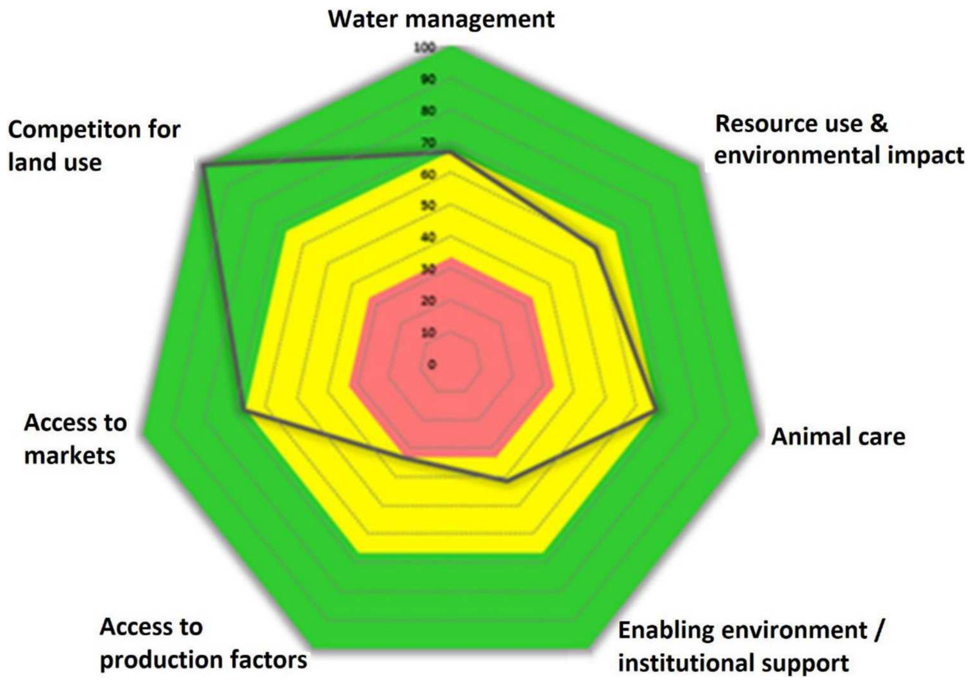

Figure 2. Example of results (radar graph) of DSAT for regional assessment of Sidama milkshed, Ethiopia.

green colour) depending on the assessors' judgement. For the choices 1, 2, 3 or 4 for each indicator, values are awarded as 0, 3.3, 6.7 and 10, respectively. These values are then added for all the indicators for a given aspect and divided by the number of indicators selected for the aspect. The average value for the aspect is then multiplied by 10 to aggregate to 100% and the results are presented in a radar graph or polygon for the selected aspects as shown in Figure 2. In addition, a summary table aggregates the results for different aspects for the three sustainability dimensions, namely environmental (planet), economic (profit) and social (people). In the radar graph, the results are colour-coded for aggregate scores of 0–33% (red), 34–66% (yellow) and 67–100% (green). Results in red indicate the urgency to improve aspects, results in yellow indicate the scope for improvement in aspects and results in green indicate aspects at acceptable levels. DSAT only gives a snapshot of the sustainability of a dairy system at different levels, based on the selection and scoring of aspects and indicators by the users. It does not give absolute scores for indicators nor how the various aspects and indicators affect the sustainability of the dairy sector. Since the development of DSAT in 2021, six workshops have been organized in Kenya (two workshops), Ethiopia, Rwanda, Tanzania and Uganda where stakeholders (farmers, extension workers, dairy cooperatives, private sector, researchers and civil servants) used the tool to assess sustainability of dairy systems at farm, cluster (regional) and national levels.

2.2. Conceptual framework for the evaluation of DSAT

This evaluation of DSAT followed the conceptual framework shown in Figure 3 which consisted of four steps, namely; (a) conducting a literature search to identify relevant indicator-based sustainability assessment tools for dairy systems in Africa; (b) creating an overview of identified tools; (c) comparative analysis of identified tools with DSAT and (d) conducting an online survey among of DSAT workshop participants or users in East Africa.

For the literature search to identify relevant tools to use for the evaluation of DSAT, the search string, used on Scopus and CAB Abstract search engines for relevant sustainability assessment tools for comparison with DSAT, was 'Dairy' AND 'Sustainability' AND 'Assessment' AND 'Africa'. The two search

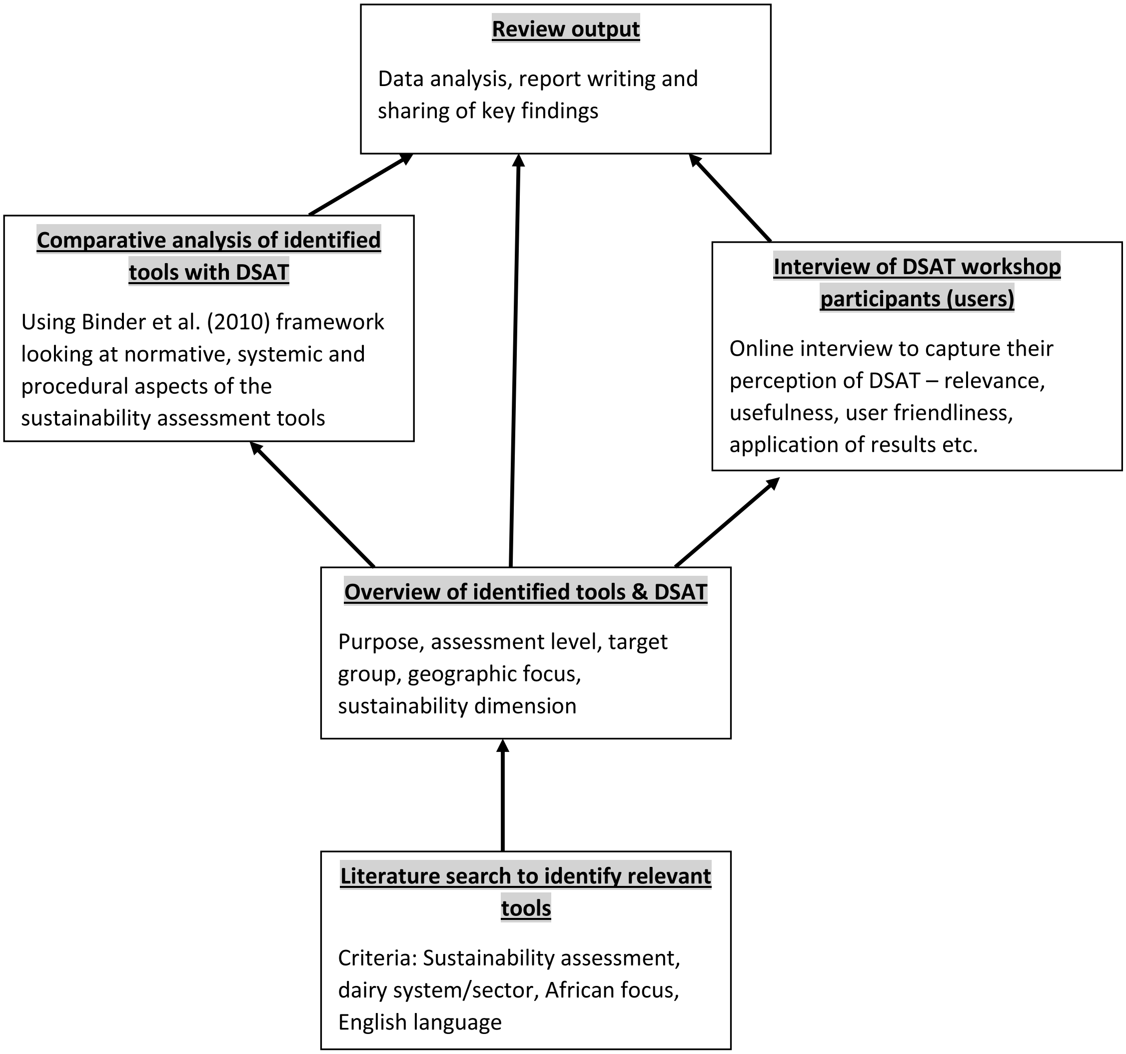

Figure 3. Conceptual framework for the evaluation of Dairy Sustainability Assessment Tool (DSAT).

engines were used as they are complementary and are commonly used. No limitations on the year of publication were used and the search was in titles, abstracts and keywords. The search resulted in 13 references from SCOPUS and 40 references from CAB Abstracts. Search results were checked for sustainability assessment tools that could be applied to dairy systems in Africa. Four dairy sustainability assessment tools were identified: one was from SCOPUS while the remaining three were from CAB Abstracts. One of the four tools called GAMEDE (Vayssières et al., 2009) was dropped for comparative analysis with DSAT because the dairy systems do not represent the dominant ones in Africa. For comparison with DSAT, the purpose, assessment level, target group, geographic focus and sustainability dimensions of each of the three tools were obtained from the publications describing the tools.

The comparative analysis of the identified tools with DSAT followed the framework of Binder et al. (2010), which was developed for evaluating sustainability assessment methods by looking at normative, systemic and procedural aspects of the sustainability assessment tools. This framework was selected as it has been described in detail (Binder et al., 2010; Marchand et al., 2014). The normative aspect addresses the sustainability concept, goal, scoring method and tool function; the systemic aspect focuses on the ability of the tool to translate the complexity of a system and the procedural aspect entails user-friendliness, data availability and effectiveness of the tool (Binder et al., 2010).

2.3. Data collection and statistical analysis

For the evaluation of DSAT by the users, we conducted an online survey during three weeks in September 2023 with a semi-structured questionnaire sent to all the users who had attended training workshops on DSAT in Ethiopia, Kenya, Rwanda, Tanzania and Uganda. Out of the 71 users from five countries that were invited to participate, 21 users completed the survey (30% response rate). The online survey was developed using Microsoft Forms and the link to the questionnaire was sent out on 7 September 2023 with an initial deadline of 20 September to complete the survey, which was extended to 27 September 2023.

Respondents were asked six open questions about the strengths and weaknesses of DSAT and about areas for improvement. In addition, they were questioned on the relevance, usefulness, user-friendliness and application of the results of DSAT via fourteen closed questions using a Likert scale from 1 to 10. To ensure that all questions were answered, response to all questions was made compulsory before the questionnaire could be submitted. Completion of the online questionnaire by the respondents took between 20 and 40 min. Responses from the online survey were downloaded from Microsoft Forms as an Excel File which was used for data analysis. The profile of the respondents is presented in Table 1.

Table 1. Profile of respondents of the online survey on perception of DSAT.

Item	No. of respondents (total = 21)
Gender	
Male	15
Female	6
Institutional affiliation	
Private sector (including dairy farms)	7
Non-Governmental Organizations (local and international)	6
University and research institutes	5
Government agency (e.g. dairy board)	3
Country	
Kenya	7
Tanzania	11
Rwanda	3
Previous experience with models and or tools for sustainability assessments	
Yes	2
No	19

Data analysis was performed with SAS 9.4 (Statistical Analysis System (SAS) Institute, 2016) using Means and Frequency Procedures for descriptive statistics. The general linear model (GLM) procedures for variance and regression analyses were used to assess whether there were relationships between the responses of DSAT users and their personal profiles in terms of gender, institutional affiliation and country. The level of significance was set at $P < 0.05$.

3. Results

3.1. Overview of tools for sustainability assessment of dairy systems in Africa

In addition to DSAT, the other three sustainability assessment tools for dairy systems in Africa that were selected from the literature search were IDEA ('Indicateurs de Durabilité des Exploitations Agricoles' or Farm Sustainability Indicators; Zahm et al., 2008), CLEANED (the Comprehensive Livestock Environmental Assessment for improved Nutrition, a secured Environment and sustainable Development; Notenbaert et al., 2020) and CLIFS (Crop Livestock Farm Simulator; Le Gal et al., 2022). Although IDEA was originally designed for farming systems in France, it has been applied in many French-speaking African countries such as Algeria and Tunisia (Attia et al., 2021; Bir et al., 2011), which made us to include the tool for the evaluation of DSAT. Generally, the common objective of these tools is to evaluate or assess the sustainability of dairy farms or systems (Table 2). CLEANED focused more on the environmental impacts of livestock enterprises while DSAT specifically had the objective of facilitating discussion and reflection on the sustainability of the dairy systems. DSAT and IDEA address the environmental, economic and social dimensions, CLIFS focuses on the environmental and economic dimensions, while CLEANED only focuses on the environmental dimension of sustainability (Table 2). Three of the four tools can be used to conduct sustainability assessment at the farm level only while only DSAT can conduct an assessment at the farm, regional and national levels. All the tools except DSAT require data from farm surveys to conduct the sustainability assessment. In the case of DSAT, the assessment relies solely on expert or practitioner opinion. Farmers are the common target group of all the tools though other groups are targeted by all the tools.

Table 2. Overview of selected tools for sustainability assessment of dairy systems in Africa.

Tool	Objective	Sustainability dimension	Assessment level	Data source	Target group	Countries applied in	Publication(s)
DSAT (Dairy Sustainability Assessment Tool)	To facilitate discussion among stakeholders on the people-profit-planet sustainability of the dairy sector in East Africa	Environmental, Economic, Social	Farm, regional, national	No quantitative data required as the tool is largely qualitative but expert opinion is vital	Farmers, extension workers, dairy cooperatives, research organizations and policy-makers	Ethiopia, Kenya, Rwanda, Tanzania and Uganda	Ndambi et al. (2020); van der Lee et al. (2022)
IDEA (Indicateurs de Durabilité des Exploitations Agricoles)	To evaluate the sustainability of farms	Agro-ecological (environmental), economic, and socio-territorial (social)	Farm	Farm survey data	Farmers, policy-makers	Tunisia, Algeria	Zahm et al. (2008); Bir et al. (2011); Attia et al. (2021)
CLEANED (the Comprehensive Livestock Environmental Assessment for Improved Nutrition, a Secured Environment and Sustainable Development)	To assess the environmental impact of livestock enterprise and farm sustainability	Environmental	Farm, regional	Farm data through focus group discussion	Farmers, policy-makers, development agencies	Tanzania	Notenbaert et al. (2020)
CLIFS (Crop Livestock Farm Simulator)	To facilitate farmers' reflection about the future direction or sustainability of their dairy or mixed crop-livestock farms	Environmental, economic	Farm	Farm survey data	Farmers, farm advisers, researchers	Madagascar, Morocco	Le Gal et al. (2022)

3.2. Comparative analysis of DSAT with similar indicator-based sustainability assessment tools

Following the framework developed by Binder et al. (2010), the normative aspect of the three indicator-based sustainability assessment tools compared with DSAT showed that DSAT shared a similar view of the sustainability concept with the other selected tools (Table 3). A sustainable dairy system is seen as environment-friendly, economically viable and socially acceptable. CLEANED seems to emphasize the environmental footprint of dairy production. Except for CLIFS, all the tools adopted a top-down approach in goal setting as stakeholders were not involved in setting the objective of the assessment. In the case of CLIFS, there is a combination of stakeholder involvement and a top-down approach. The scoring method of DSAT is similar to that of IDEA as both are based on scoring of indicators for the selected aspects (components in IDEA) of sustainability which are then aggregated into total scores of between 0 and 100% for each aspect (Table 3). The higher the aggregate score for each aspect (component), the better it is in terms of the sustainability status of the dairy farm. Both CLEANED and CLIFS do not aggregate the scores for the indicators but the sustainability status of the dairy farm is based on either environmental footprint or nutrient balances of the farm. In terms of the tool function, both DSAT and IDEA have communication and learning functions. Both tools can facilitate communication among the stakeholders and with policy-makers on threats to sustainability and potential measures to address them. Besides, they provide an opportunity for learning about sustainability issues of the farm or system being assessed and the process in holistic assessment of the sustainability of dairy systems. DSAT does not have a monitoring function, that is tracking of performance over time, unlike CLEANED and CLIFS.

Regarding the systemic aspect of the tools according to the framework of Binder et al. (2010), the implicit goal of DSAT is simplicity which is necessary to achieve the objective of facilitation of discussion among dairy sector stakeholders in East Africa. Other tools used for comparison in this study (IDEA, CLEANED and CLIFS) also shared a similar goal of simplicity. In terms of sufficiency of the tool, the explicit goal of DSAT is to provide a holistic sustainability assessment which is evident from a comprehensive list of aspects (14 themes) and 54 indicators included in the tool. IDEA has a similar explicit goal of holistic sustainability assessment, but CLEANED and CLIFS do not have such a goal given the limited number of indicators (less than ten) included in the tools.

According to the framework of Binder et al. (2010), the procedural aspect of the sustainability assessment tool includes a preparatory phase, a phase of indicator selection, a measurement phase, an assessment phase and applicability of assessment results and follow-up phase. In the preparatory phase to use DSAT, six stakeholder workshops of 6–8 hours were organized in Ethiopia, Kenya (two workshops), Rwanda, Tanzania and Uganda between 2022 and 2023. The average attendance per workshop was between 12 and 20 persons and the total number of attendees was 71. The DSAT tool was first demonstrated in the workshops, followed by the assessment of dairy systems at the farm, regional or national level. For DSAT and the other three tools, there was no phase of participatory selection of indicators as a standard set of indicators to be used are already included in the tools. However, DSAT allows for the deselection of inappropriate indicators in the assessment phase. For the measurement phase, the accuracy of input data used in DSAT is moderate because the influence of the perception of the assessor and data availability depends on the knowledge of the assessor because there is no requirement for quantitative data input for the sustainability assessment by the tool. This implies that the input data for DSAT are based on the subjective assessment of the assessor and the assessor can do a more accurate assessment if (s)he knows more about the systems. DSAT is generally user-friendly as limited time investment is required to understand the tool and the manual (Table 3). The transparency of the assessment phase of DSAT is moderate as the scores for the indicators of each selected aspect depend largely on the assessor's interpretation. This is similar even for the assessment using farm data in the case of CLEANED and CLIFS because the output accuracy depends on the quality of the farm data used by the assessors. The accuracy of DSAT output is moderate because the assessment is based on the knowledge of the dairy systems of the assessor(s) and it is qualitative unlike CLEANED and CLIFS which use quantitative data for the assessment. Despite the moderate level of DSAT output accuracy, the output is highly relevant for a quick assessment of the sustainability of dairy systems.

Table 3. Comparative analysis of four indicator-based sustainability assessment tools based on a framework adapted from Binder et al. (2010).

Aspect of tool	Characteristic	DSAT	IDEA	CLEANED	CLIFS
Normative aspect	Sustainability concept	Meet people (socially acceptable), profit (economically viable) and planet (environment- friendly) objectives	Economic viability, social livability, environmental reproducibility	Farm production with a minimal environmental footprint	Farming system that is productive and profitable while promoting biodiversity
	Goal setting	Top-down approach	Top-down approach	Top-down approach	Combination of stakeholder involvement and top-down approach
	The scoring and aggregation method	The scoring method with indicators for each sustainability aspect ranging between 1 and 4. Aggregation of average scores into selected sustainability aspects ranging from 0 to 100 presented in a radar graph covering people (social), profit (economic) and planet (environment) dimensions. The higher the aggregate score for each dimension the better for sustainability	The scoring method with indicators for each of the ten components covering the 3 sustainability dimensions (agro-ecological, socio-cultural and economic). The maximum value is set for each indicator so that the sum of indicator scores for each sustainability dimension does not exceed 100. The global sustainability score is then calculated for each sustainability dimension.	The scoring method with six indicators which are used to assess nutrient balance, water use and GHG emissions of the dairy farm. There is no aggregation of the indicators' scores but the sustainability of the farm in terms of the environmental footprint is based on the results of environmental impact assessment compared to the reference values.	The scoring method based on indicators (input parameters) using data from farm surveys. There is no aggregation of the outputs to show the sustainability status of the farms being assessed but the results of the nutrient balances (food, forage and manure) and farm profitability for different scenarios provide a pointer as to the sustainability status of the farms.
	Tool function	Communication and learning function	Communication and learning function	Monitoring, communication and management function	Monitoring, communication, and management function
Systemic aspect	Simplicity	Implicit goal as it aims to facilitate discussion among dairy sector stakeholders in East Africa	Implicit goal of the developer as it should be accessible to many	Implicit goal as it is meant for farmers, development practitioners, policy-makers and researchers	Implicit goal as it aims at facilitating farm management decisions
	Sufficiency (complexity)	Explicit goal as the tool aims to provide a holistic sustainability assessment	Explicit goal as the tool aims to provide a holistic sustainability assessment	No clear goal as the tool only includes a limited number of indicators	No clear goal as the tool only includes a limited number of indicators
	Indicator interaction	Not explicit	Not explicit	Not explicit	Not explicit
Procedural aspect					
(i) Preparatory phase		Organizing stakeholders' workshop to demonstrate the tool	Establish contact with farmers and plan farm visits to collect data	Plan focus group discussion to collect farm data	Plan farm visits to gather data on the initial farm scenario and production target
(ii) Indicator selection phase		Not included as a standard set of indicators is used	Not included as a standard set of indicators is used	Not included as a standard set of indicators is used	Not included as a standard set of indicators is used
(iii) Measurement phase	Data correctness	Moderate due to the influence of the perception of the assessor(s)	Farmers' knowledge might be influenced by perceptions	Farmers' knowledge might be influenced by perceptions	Moderate due to the influence of farmers' perception

(*Continued*)

Table 3. Continued.

Aspect of tool	Characteristic	DSAT	IDEA	CLEANED	CLIFS
	Data availability requirements	Moderate, depending on the knowledge of the assessor(s)	Good data are available from farm records and through interviews	Moderate, depending on data collected through focus group discussion	Moderate depending on data gathered from farm records and through interviews
	User-friendliness	Limited time investment to understand the tool and manual	Limited time investment to understand the tool and manual	Limited time investment to understand the tool	High time investment to understand different modules in the 4 Excel sheets and to interpret the results
(iv) Assessment phase	Transparency	Moderate transparency as the scores depend on the assessor's interpretation of the indicators	High transparency in scoring method and aggregation	Moderate transparency as the indicator values depend on farm data used by the assessor	Moderate transparency as the indicator values depend on farm data used by the assessor
(v) Applicability of assessment results and follow-up	Output accuracy	Moderate depending on the knowledge of the assessors of the assessed dairy system and due to the qualitative nature of scoring of the indicators	Moderate as the scoring of the indicators might be influenced by the farmers' perception	High due to input of quantitative farm data, involvement of experts and scientific reference in the development of the tool	High due to input of quantitative farm data, involvement of experts and scientific reference in the development of the tool
	Relevance	Output is highly relevant to the quick assessment of the sustainability of the assessed dairy system	Highly relevant as the outcomes can be used for decision-making and management of the farm	Highly relevant for rapid environmental impact assessment of dairy farm or enterprise	Highly relevant as the outputs of different scenarios can be used for decision-making and management of the farm

3.3. Evaluation of DSAT by the users

Of the 21 respondents that completed the survey, six respondents were female and 15 respondents were male (Table 1). Seven, eleven and three of the respondents were from Kenya, Tanzania and Rwanda, respectively. The professional background of the respondents was mixed: seven were from the private sector including commercial dairy farms, six were from local and international non-governmental organizations, five were from universities and research institutions and the remaining three respondents were from government agencies, particularly dairy boards. Only two of the 21 respondents had experience with using the sustainability assessment model/tool. According to the respondents, the major strengths of DSAT were the provision of a good overview of the sustainability of dairy systems in East Africa ($n = 10$), the involvement of different dairy stakeholders in the assessment ($n = 12$), the aspects covering a wide scope important to the sustainability of dairy systems at different levels ($n = 10$) and that it facilitates discussion on the sustainability of dairy systems ($n = 8$) (Table 4). The major weaknesses of DSAT according to the respondents were the subjective scoring of indicators ($n = 13$), absence of numerical reference values for scoring of indicators ($n = 7$), absence of guidance on what to do with the assessment results ($n = 10$) and the inability to address external shocks that can undermine the sustainability of dairy systems ($n = 8$), for example, climatic and market shocks (Table 4). In Figure 4, the summary of the Strength, Weakness, Opportunity and Threat (SWOT) analysis of DSAT is presented.

To improve DSAT, some respondents suggested expressing the indicators in measurable values instead of four levels ranging from low to high ($n = 10$) and making the interpretation and scoring of indicators independent of the assessors which implies eliminating subjectivity in the scoring of the indicators ($n = 12$). There were also suggestions of translating the tool into the major local languages in East Africa ($n = 6$), for example into Swahili to make it easy for its use by farmers who are not proficient in English and adding guidelines to the tool of what can be done with the results of the assessment ($n = 12$). The results of the evaluation of the relevance, user-friendliness and application of assessment results by DSAT users showed that the distinction of four indicator levels from 1 (poor/low) to 4 (high/good) had the lowest score based on the scale of 0–10 (Table 5). The highest score by the respondents was for the question of

Table 4. Strengths and weaknesses of DSAT and suggestions for improvement from the responses of Dairy Sustainability Assessment Tool users in Kenya, Rwanda and Tanzania (number of respondents = 21).

Strength	Weakness	Suggestions for improvement
• Allow for the involvement of different dairy stakeholders in the assessment (*n* = 12)	• Scoring of indicators is subjective and can be biased depending on the assessor's perception (*n* = 13)	• Interpretation and scoring of indicators should be independent of the assessors (*n* = 12)
• It can guide decisions on bottlenecks to sustainability to be addressed (*n* = 5)	• It may be difficult for farmers to use as most have a low level of formal education and this may be the case for some extension staff (*n* = 7)	• The tool should be translated into major local languages like Swahili to make it easy for use by farmers (*n* = 6)
• It combines the 3 pillars of sustainability (social, economic and environmental) (*n* = 6)	• Absence of numerical reference values for scoring of indicators (*n* = 7)	• A simpler version can be developed for use by those with a low level of formal education (*n* = 5)
• The aspects cover a wide scope important to the sustainability of the dairy system at different levels (*n* = 10)	• Quantification of most indicators is challenging as the scores are a Likert scale of 1–4 (low/poor to high/good score) (*n* = 5)	• There is room to simplify the explanation of aspects and indicators to eliminate many jargons (*n* = 4)
• Captures information that can help to prioritize issues to address for sustainable dairy production (*n* = 4)	• Does not address external shocks that can undermine the sustainability of the dairy system, for example, climatic and market shocks (*n* = 8)	• Add guidelines of what can be done with the results of the assessment (*n* = 12)
• It helps to have a better understanding of sustainable dairy farming (*n* = 7)	• Absence of what to do with the results of the assessment (*n* = 10)	• Indicators should be expressed in measurable values to reduce subjectivity in scoring by not depending solely on the perception of the assessors (*n* = 10)
• It facilitates discussion on the sustainability of the dairy system (*n* = 8)		
• It can assist in decision-making on investment in the dairy sector (*n* = 4)		
• It provides a good overview of the sustainability of the dairy system (*n* = 10)		

whether the indicators used for different aspects were clear and easy to understand (average score = 7.90). The lowest score was for the question of whether the scale of four levels describes the right variation of the indicator (average score = 6.33). Generally, the average scores for various closed questions ranged between 6 and 8 (Table 5). Gender, institutional affiliation and country did not significantly affect the average scores for any of the closed questions.

4. Discussion

4.1. Overview of tools for dairy sustainability assessment in Africa

The paucity of tools for sustainability assessments of dairy systems in Africa found in the literature search is a confirmation that most of these tools have been designed for farming systems in the global North. For example, when 'Africa' was removed from the search string in SCOPUS and CAB Abstracts, the search results were 562 and 642, respectively compared to 13 and 40 search results when Africa was added to the search string. Besides, in a review of sustainability assessment tools at the farm level, De Olde et al. (2016) listed 48 tools but only 7 of these tools could be applied to African farming systems of which only one (IDEA) could be used for smallholder dairy systems in Africa without requiring any major modification. Tools, such as RISE (Response Induced Sustainability Evaluation; Hani et al., 2003), SAFA (Sustainability Assessment of Food and Agriculture Systems; FAO, 2013) and MOTIFS (Monitoring Tool for Integrated Farm Sustainability; Meul et al., 2008) can be applied to dairy systems in Africa but they would require modifications, which is one of the reasons for the development of DSAT to address the African dairy farming context. Besides the challenge of adapting the tools to suit the African context, the other challenge with the above tools is the data requirements given that smallholder dairy farmers in Africa generally do not keep farm records (Atanga et al., 2013) that are required as input by these tools. To address this challenge, farm data collection is often part of the indicator measurement phase of the sustainability assessment tool for dairy systems in Africa in tools selected in this study for the evaluation of DSAT, such as IDEA, CLEANED and CLIFS. Another challenge of applying tools developed in the global North to farming systems in Africa is the reduced accuracy of the outputs due to different contexts (van der Linden et al., 2020). Furthermore, the paucity of tools found in the literature search could also be attributed to the English language restriction in the search string as there may be sustainability assessment tools for dairy systems in Africa published in other languages, particularly in French. The paucity of tools found in the literature search highlights the challenge of evaluation of sustainability assessment tools for Africa as most tools are designed for farming systems in the global North.

4.2. Comparative analysis of DSAT with other sustainability assessment tools

Compared to other sustainability assessment tools for dairy systems in Africa, DSAT has a similar implicit goal of simplicity to ensure usefulness to a wide range of stakeholders. However, balancing simplicity with the sufficiency of the tool to achieve a holistic sustainability assessment is a challenge as a holistic assessment requires a broad consideration of the three sustainability dimensions (environmental, economic and social; van Ittersum et al., 2008). Although integrating environmental, economic and social themes in sustainability assessment tools is important for a holistic assessment, environmental themes and tools generally receive more attention (De Olde et al., 2016) as in our study where all four tools addressed environmental themes, but not all of them addressed social themes. Generally, a holistic assessment can provide a good overview of the sustainability of the farming systems as in the case of DSAT for dairy systems in Africa but quite often may raise many issues to improve the system's sustainability. Addressing many issues at the same time may be difficult for dairy actors, for example, farmers, given resource constraints inherent to smallholder dairy production systems in Africa. This raises the need for prioritization of sustainability issues to address based on the perception of the stakeholders (Lindfors, 2021). In addressing this, Lindfors (2021) suggested weighting sustainability aspects (themes) to rank them. These weights can be used to represent the importance of each aspect (criterion) in relation to others. The most common approach in weighing different aspects is to engage stakeholders. In addressing this, DSAT chose to weigt the sustainability aspects by ranking the aspects by stakeholders. Besides, to help decision-making by the stakeholders, the sustainability assessment tool could provide guidelines on how to use the results to achieve sustainability. Another challenge with a holistic sustainability assessment is that it may not often be in-depth compared to assessments that focus on one dimension of sustainability, for example, the environment (De Olde et al., 2016).

The selection of indicators in DSAT and tools selected in this study was not participatory, that is the stakeholders were not involved in the decision on indicators for different aspects or components to include in the tools. This implies the users of DSAT have to select from a standard set of indicators provided in the tool for each selected aspect of the assessment, which can undermine the comprehensiveness of the assessment as was observed by Lindfors (2021) as some aspects and associated indicators are left out or are framed in a different way than users would frame them. For example, during DSAT workshops, some participants had wanted to include all the aspects and the associated indicators to have more comprehensive results. According to them, all the aspects matter for the dairy farm. Besides, the outcomes may be different with different sets of aspects and indicators selected. However, selecting from a standard set of indicators provided is also reported by the other tools DSAT was compared to. Participation of the stakeholders in the selection of indicators for assessment tools is essential to achieving reliable and relevant assessment outcomes (Chopin et al., 2021). In addition, it will enhance the methodological transparency of the assessment tool and will make results meaningful (Marinus et al., 2018), that is the users understand how results were generated and how they should be interpreted (Lindfors, 2021). Perhaps DSAT can provide room for the addition of relevant indicators by the users (up to a certain number) per aspect to ensure capturing local specificities in addition to the standard set of indicators provided in the tool. Therefore, allowance for the addition of relevant indicators to the tool by the users should be given serious consideration to improve DSAT. For example, for the aspect of water management, the indicators in DSAT are agricultural water availability, water quality and social conflicts over water, to which assessor(s) may want to add access to water or water governance as an indicator as water may be available but may not be accessible due to access rights. This observation may be applicable to indicators under other aspects of DSAT. However, the main challenge is programming the additional indicators in the tool.

The correctness of data used for assessment by DSAT calls for close attention as it is dependent on the knowledge of the assessors and this largely determines the output accuracy. Based on the professional background of the respondents in the online survey (Table 1) who were sampled from the participants at the DSAT training workshops, it could be deduced that the assessors had a good knowledge of the dairy sector in their country and the data provided by them may be reliable. To enhance the correctness of the data, there were discussions among the users during group assessments in the workshops on the scoring of the indicators for each aspect to arrive at a consensus on the scores. In the case of individual assessments, the bias of the assessors in scoring the indicators may be much more prominent. Perhaps an individual assessment should be discouraged just as in IDEA, CLEANED and CLIFS, where a team of different users including the farmer whose dairy farm is to be assessed is involved in the preparatory phase of planning for farm data collection. This approach, of course, has its own danger of domination by the researcher(s) in data collection. Another disadvantage of this method is that multiple persons are required for an assessment. When DSAT users are well-trained and have discussed how to score indicators, they can assess farms on their own, which reduces labour costs.

4.3. Evaluation of DSAT by the users

There was a generally positive response (scores of between 6 and 9 on a scale of 0–10) by the respondents in the online survey on the relevance of DSAT for dairy systems in Africa (Table 5). One of the strengths of DSAT mentioned by the respondents is that it provides a good overview of the sustainability of dairy systems in Africa. The comprehensive list of aspects (themes) of sustainability included in the tool also enhances a holistic assessment of dairy systems. Moreover, the tool is user-friendly compared to the other selected tools as it requires a limited time investment to understand and conduct the assessment (Table 3). Assessment with the tool entails only a few steps that are easy to follow. The user-friendliness of DSAT was also confirmed by the interviewed users (Table 5).

The major weaknesses of DSAT (Table 4) mentioned by the respondents are consistent with the evaluation based on the framework developed by Binder et al. (2010). The weaknesses were mainly about the subjective scoring of indicators and the absence of numerical reference values for scoring a number of indicators. The weakness that DSAT does not address external shocks that can undermine the sustainability of dairy systems, for example, climatic and market shocks, is a legitimate one given the menace of climate change in Africa. This should be addressed to improve DSAT to respond to the effects of climate change on dairy systems in the continent. An aspect can be added to DSAT on the resilience of dairy systems with some indicators of resilience. According to the resilience indicator framework proposed by Engle et al. (2014), some relevant indicators include exposure to climatic shocks (frequency and severity of drought and/or flood), coping strategies (individual preparedness strategies, recovery ability and access to early warnings), mitigation plans (access to insurance, quality of insurance) and living conditions of the household (poverty status and health status).

The low response rate in this study to the online survey of about 30% of the DSAT workshop participants might have masked differences in the responses of the respondents across gender, institutional affiliation and country. As observed by Wright (2005), one of the major disadvantages of online surveys is generally the low response as it is difficult to motivate the respondents. In this study, we sent three reminders to the DSAT users within three weeks to achieve the number of respondents reported. Although the response rate was low, the general trends of the results in terms of strengths and weaknesses of DSAT would likely be the same even with a higher response rate but it is probable a higher response rate may reveal gender and country differences. Another issue with the online survey in this study is

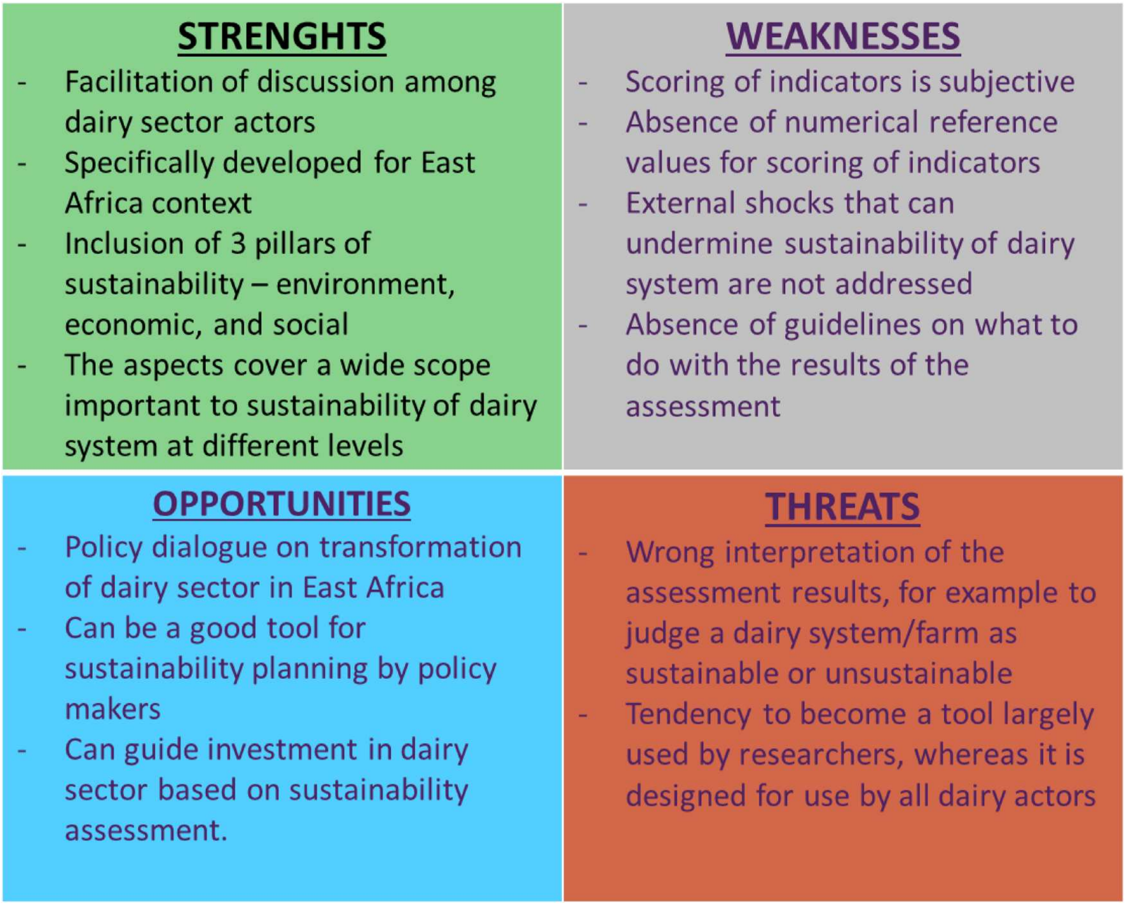

Figure 4. Strength, Weakness, Opportunity and Threat (SWOT) analysis of the Dairy Sustainability Assessment Tool (DSAT).

Table 5. Evaluation by DSAT users of its relevance, user-friendliness and application of results on a scale of 0 (Poor) to 10 (Excellent)[a].

Question	No of respondent	Average score	Minimum	Maximum
1. Does DSAT present the questions in an easy and understandable way?	21	7.14	5	8
2. Are the results of DSAT a true reflection of the dairy farm or dairy sector in your region or country?	21	7.33	4	9
3. Is the required information (data) by DSAT for the assessment easy to supply?	21	6.71	4	9
4. Are different sections of DSAT clear and easy to navigate?	21	7.19	5	9
5. Do you understand the results of DSAT?	21	7.52	4	9
6. Does the tool present the results in an easy and understandable way?	21	7.43	4	9
7. Do you consider the results of DSAT to be accurate?	21	7.38	5	9
8. Are the aspects of DSAT clear and easy to understand?	21	7.71	4	9
9. Are the indicators used for different aspects of DSAT clear and easy to understand?	21	7.90	5	9
10. Do the indicators rightly reflect their corresponding aspects?	21	7.76	5	9
11. Are the indicators relevant to the sustainability assessment of dairy in your region or country?	21	7.86	6	9
12. Are the indicators clearly defined and understandable?	21	7.77	5	9
13. Are the scores for the indicators reasonable?	21	7.71	4	9
14. Does the scale of four levels describe the right variation of the indicator?	21	6.33	4	9

[a]GLM procedure showed that gender, institutional affiliation and country did not have a significant effect ($P < 0.05$) on the average scores.

that there is the likelihood that those who responded were those who are really interested in the tool, which could partly explain the general positive perceptions of DSAT.

DSAT has room for improvement as suggested by the users. Their suggestions should be given due attention to enhancing the quality of assessment outputs, particularly in making the scoring of the indicators independent of the assessors' perception (Table 5). To address this, the indicators could be quantified to reduce subjectivity in scoring. Quantification of the indicators, as observed by the respondents, instead of the qualitative nature of scoring of the indicators based on four levels ranging from low/poor to high/good, could be a way to further improve the tool. Expressing the indicators in measurable values will reduce dependence on the perception of the assessors in scoring the indicators. Besides, data accuracy is generally enhanced when the indicators are quantified (Lindfors, 2021).

DSAT could be further improved by adding guidelines of what can be done with the results of the assessment as presented by the visual representation in a coloured radar graph depicting the sustainability status of different aspects of the dairy farm. This gap in the design of the DSAT was pointed out by the users interviewed as one of its major weaknesses. Adding guidelines to the tool of what can be done with the results of the assessment will improve its user-friendliness and can facilitate the application of the results by the users. Addressing these suggestions by the respondents on the areas of improvement necessitates updating of DSAT. This may be necessary too for other sustainability assessment tools for dairy systems in Africa, or farming systems in general, to remain fit-for-purpose and to ensure that assessment outcomes are reliable and relevant. Crucial to this improvement is stakeholder participation right from framing sustainability to selection and scoring of indicators and interpretation of the assessment output.

5. Conclusions

The DSAT has been developed to address some of the sustainability issues regarding dairy systems in East Africa with potential for wider application to other regions of Africa. In this study, we conducted an evaluation of DSAT to identify its strengths and weaknesses based on the perceptions of its users and compared its main features with three similar dairy assessment tools for Africa (IDEA, CLEANED and CLIFS), based on a common framework. This paper adds to the literature on the evaluation of tools, whereas most of the literature on this topic just describes the tools or applications of tools to case studies. DSAT was different from other tools compared with as it does not require input data from farm surveys as the assessments rely on expert opinion, and it can conduct assessments at farm, regional and national scales. There was a generally positive response by the respondents regarding the relevance of DSAT for dairy systems in Africa as it provides a good overview of the sustainability of dairy systems in Africa through its holistic assessment. The user-friendliness of DSAT was also confirmed by the users. The major weaknesses of DSAT mentioned by the respondents were consistent with the evaluation based on the framework developed by Binder et al. (2010). The weaknesses were mainly about subjective indicator scoring and the absence of numerical reference values for indicator scoring. This evaluation has shown that DSAT has room for improvement as suggested by the users, particularly in making the scoring of the indicators independent of the assessors' perception and adding guidelines to the tool on what can be done with the results of the assessment. To improve DSAT, the identified weaknesses could be addressed, as proposed in the paper, while maintaining the simplicity of the tool.

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Appendix. Sustainability aspects or themes and indicators in Dairy Sustainability Assessment Tool

Aspect	Indicator
1. Soil health	Soil organic matter, soil acidification, soil erosion, soil compaction
2. Water management	Agricultural water availability, water quality, social conflict over water
3. Biodiversity	Agro-biodiversity, dairy cattle genetic diversity, biodiversity loss in the landscape
4. Resource use and environmental impact	Nutrient balance, manure management, use of agro-chemicals, renewable energy use, GHG emissions
5. Animal care	Animal health, cow comfort
6. Impact on human health and nutrition	Food and nutrition security, food safety, zoonotic disease control
7. Livelihood opportunities	The average age of dairy farmers, youth employment opportunities in the dairy sector, gender balance in dairy activities, social status of dairy
8. Voice in decision-making at different levels	Farmer membership of farmers' organization, the influence of dairy farmers in shaping the formal market, the influence of dairy farmers and value chain actors in regulatory processes
9. Enabling environment/ institutional support	Institutions available to deal with major shocks, budget invested in research, extension and education benefiting dairy sector, level playing field, essential infrastructure services
10. Access to production factors	Access to credit, financial autonomy (debt level), availability and skill level of household and hired labour, availability, access to and utilization of land
11. Access to market	Access to output market, access to farm inputs, access to farm services
12. Profitability	Dairy farming income, acceptable and competitive dairy prices
13. Self-sufficiency in milk production	Contribution to demand for dairy products, meeting future demand for dairy products
14. Competition for land between human food and animal feed	Proportion of land used for forage or grazing that could be used for food crops, feed availability