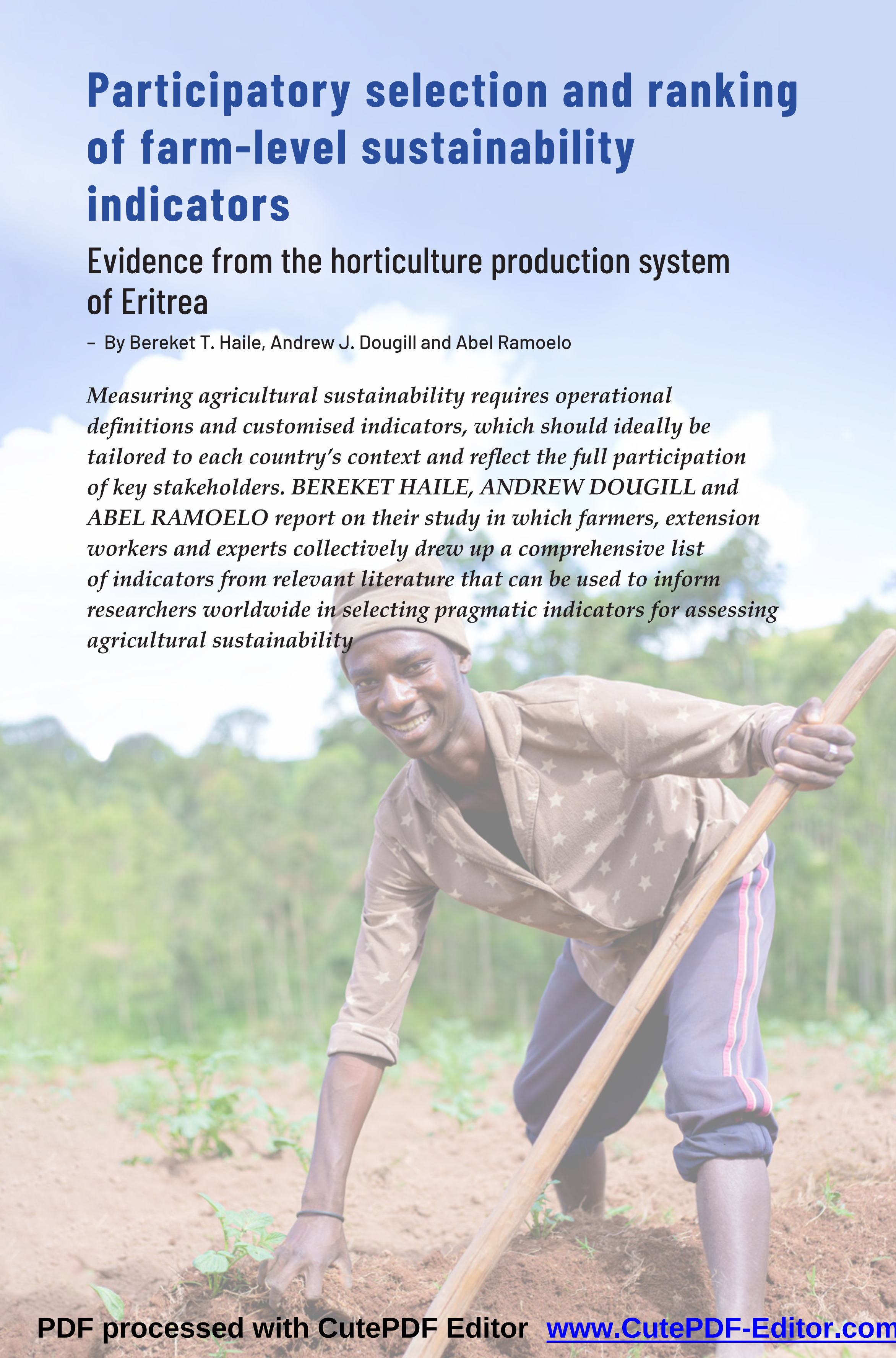
Participatory selection and ranking of farm-level sustainability indicators

Evidence from the horticulture production system of Eritrea

– By Bereket T. Haile, Andrew J. Dougill and Abel Ramoelo

Measuring agricultural sustainability requires operational definitions and customised indicators, which should ideally be tailored to each country's context and reflect the full participation of key stakeholders. BEREKET HAILE, ANDREW DOUGILL and ABEL RAMOELO report on their study in which farmers, extension workers and experts collectively drew up a comprehensive list of indicators from relevant literature that can be used to inform researchers worldwide in selecting pragmatic indicators for assessing agricultural sustainability



Introduction

Evaluating the sustainability of agricultural practices has long been a pressing research question, yet it continues to face significant methodological and conceptual challenges (Bell & Morse, 2008). Effective measurement of agricultural sustainability requires the selection of indicators that are not only scientifically robust but also contextually relevant (Reed *et al*., 2008). In response, numerous studies have demonstrated that participatory approaches can enhance the acceptance and legitimacy of sustainability initiatives, as stakeholders are more likely to support and implement indicators when they have been involved in their selection (Luján Soto *et al*., 2020; Roy *et al*., 2013; Yegbemey *et al*., 2014). Therefore, it is recommended to develop indicators that are tailored to each specific context, with full and transparent participation from both local and national stakeholders (Reid & Rout, 2020). Such approaches enable the development of locally agreed-upon indicators through a methodologically sound process, with thresholds defined by consensus among key stakeholders.

Initial sustainability studies used methods and indicators mostly crafted by experts (Syers *et al*., 1995; Taylor *et al*., 1993). However, recent advances have focused on participatory selection and evaluation of sustainability indicators of a particular agricultural practice including putting thresholds and weights to the indicators (Eze *et al*., 2022; Hermans *et al*., 2021; Luján Soto *et al*., 2020). This is mainly because the involvement of key stakeholders in the selection process fosters a sense of ownership among those who are concerned about sustainability initiatives with indicators chosen to reflect the local needs and priorities.

Several studies have attempted to summarise and synthesise the various agricultural sustainability indicators proposed and applied by researchers (Bathaei & Štreimikienė, 2023; Hayati, 2017). There are only limited studies to date in Africa which have followed participatory approaches in selecting sustainability indicators (Asare-kyei *et al*., 2015; Marandure *et al*., 2020; Reed & Dougill, 2002; Yegbemey *et al*., 2014). Such studies highlight the importance of frameworks and methods to include the perception of wider stakeholders and the socioeconomic and environmental context of the study area in constructing sustainability indicators usable in specific regions of Africa. A standard method for engaging multiple stakeholders in the participatory process of sustainability assessment has yet to be established, but certain best practices and guiding principles have been identified. Reed *et al*. (2006) recommend an adaptive shared learning process that involves local communities. Indicators developed by farmers and frontline extension workers are typically easy to understand but usually lack objectivity and are difficult to measure using replicable methods. Expert-led indicators on the other hand are scientifically rigorous but difficult to be understood and applied by farmers (Reed *et al*., 2006). Similarly, Reed and Dougill (2002) propose the use of a participatory shortlisting method, whereby a comprehensive list of indicators sourced from the scientific literature is subjected to a collaborative evaluation and refinement process together with local communities.

Once indicators are shortlisted through a participatory approach, their scientific soundness can be validated by selected experts who have knowledge of the local environment and have the required expertise in the concerned aspect of sustainability (Fraser *et al*., 2006; Roy & Chan, 2012; Van Calker *et al*., 2005). In this way, it is possible to develop sustainability indicators that reflect the diverse perspectives and priorities of a wide range of stakeholders which can lead to a locally appropriate and more effective sustainability assessment.

Horticultural crop production is growing to meet the increasing urban food demands across the world and especially Africa. It requires intensive land and resource utilisation, including significant groundwater extraction and high inputs of energy, fertilizers and pesticides, leading to sustainability challenges such as soil degradation and water contamination (Bergstrand, 2010; Wainwright *et al*., 2014). Additionally, the sector is highly susceptible to market fluctuations due to the perishable and bulky nature of produce, which poses economic risks (Etefa *et al*., 2022; Ghebreslassie *et al*., 2014). The seasonal and labour-intensive nature of horticulture also makes it reliant on a largely unskilled workforce, intersecting with various social sustainability challenges (Wainwright *et al*., 2014). Therefore, assessing the sustainability of horticultural practices requires a comprehensive approach that considers these multifaceted challenges.

Eritrea is a suitable case study nation as horticulture is fast-growing, and based on an input-intensive production system (MoA, 2006), yet an integrated sustainability assessment that incorporates economic, environmental and social dimensions has not been previously attempted. This study aims to meet two main objectives: a) to develop a set of indicators, representing the economic, environmental and social aspects of sustainability, customised for the horticulture production system of Eritrea, with the intention of providing the guidance required for a comprehensive assessment of horticultural crop farming sustainability at the farm level; and b) to assess the perceptions of different stakeholder groups in the relative importance of the indicators in measuring sustainability of horticulture farming.

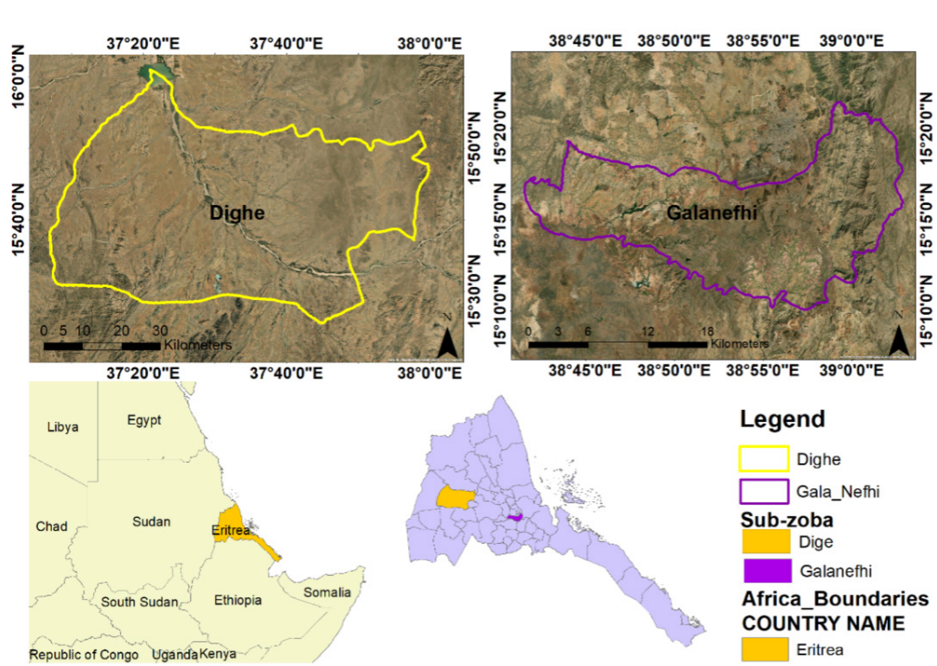
The methodological framework used in this study, centred on stakeholder-engaged indicator development, presents a scalable and adaptable model that can be applied in diverse international settings, especially in regions with similar agroecological conditions. The findings from this research can therefore serve as a critical benchmark for Eritrea and similar nations, guiding policy interventions and fostering international collaborations aimed at enhancing the sustainability of horticultural agriculture.

Materials and methods

Study area

Eritrea is located in the northeastern part of Africa with a population of approximately 3.6 million of which about 69% are living in rural areas (National Statistics Office [NSO], 2013; UNSA, 2021). The country is divided into six administrative regions called *zobas*. This study focuses on two sub-*zobas*, namely Gala Nefhi and Dighe, representing the two agroecological zones with the highest potential of producing horticultural crops, i.e., the Central Moist Highland and the Western Moist Lowland (Figure 1). Reports from the Ministry of Agriculture show that sub-*zobas* Gala Nefhi and Dighe recorded the highest average horticultural crop production in their respective *zobas* (MoA, 2022).

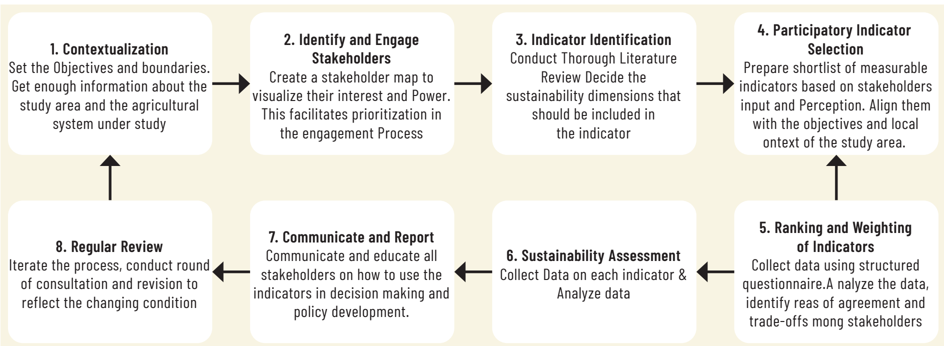
Figure 1. Eritrea, showing the location of the study area



This study employed an iterative research process that actively involved multiple stakeholders from Eritrea's horticulture production system. To facilitate the selection of sustainability indicators, a three-day participatory workshop was organised in March 2023. The workshop was attended by 35 participants, comprising five females and 30 males, who represented all key stakeholder groups in Eritrea's horticulture sector.

Figure 2 shows a logical framework which outlines the sequence of activities followed in this study. It elaborates on the iterative approach followed from the conceptualising of the concept through the participatory engagement process up to the mechanisms of collecting feedback from stakeholders and reviewing the process.

Figure 2. Logical framework of analysis



Modified by the authors based on Frater & Franks, 2013; Luján Soto et al., 2020; Reed & Dougill, 2002. (NB. Only stages 1–5 reported in this paper).

Identification of participants

The initial identification of key stakeholders was grounded in a stakeholder analysis conducted during the review of national agricultural policy documents (MoA, 2006). This document had previously identified stakeholders and clustered them into task groups to assist in policy development. Consequently, the stakeholders identified within the context of horticultural crop production served as the primary basis for inviting participants to the workshop.

The workshop brought together a broad spectrum of stakeholders, including farmers and heads of producers' associations (5), frontline agricultural extension workers (4), representatives from the Ministry of Agriculture headquarters (4), representatives from regional offices (4), planners and policy experts (4), agricultural inspectorates from the Regulatory Services Department (2), researchers and academics (3), representatives from the Ministry of Land, Water and Environment (3), international development partners (3), representatives from the Eritrean Women Association in Agribusiness (2) and a representative from the Ministry of Local Government (1). The participants were heterogeneous in terms of representation and technical expertise which is crucial in enabling a comprehensive multi-stakeholder analysis of horticulture production systems.

Preparation of Stakeholders Matrix

As a first activity the workshop participants were asked to define the stakes and roles of each stakeholder. To enhance this, the participants collaboratively developed a Mendelow's Stakeholder Matrix, a tool designed to visualise the interests and power dynamics of each stakeholder group (Mendelow, 1991). By plotting stakeholders based on their power and interest levels, the Matrix provided a clearer understanding of the varying degrees of power and interest held by different stakeholders within the horticultural subsector. The visual representation of the Stakeholder Matrix, as shown in Figure 3, was instrumental in ensuring that key stakeholders in the horticulture sector were considered in this study.

Selection of indicators

To identify appropriate indicators for the horticulture sector of Eritrea, a long list of indicators divided into economic, environmental and social group were prepared from the United Nation's Food and Agricultural Organisation (FAO) guidelines in Sustainable Assessment of Food and Agricultural Systems (SAFA) (FAO, 2012). The FAO-SAFA framework was selected for this study as it offers a comprehensive set of 116 indicators across 21 themes and 58 sub-themes. The framework's holistic approach ensures the inclusion of all dimensions of sustainability (environmental, social, economic and governance) necessary for a thorough assessment at the farm level. The FAO-SAFA framework has been field tested in various contexts which ensures its reliability and validity (FAO, 2013). Several studies, such as Soldi *et al*. (2019) in Paraguay, Gayatri *et al*. (2016) in Indonesia, Al Shamsi *et al*. (2019) in the United Arab Emirates and Italy, demonstrated the effectiveness of the tool in providing a comprehensive list of indicators to assess agricultural sustainability. Its adaptability allows it to tailor the indicators to the horticulture production system of Eritrea, while promoting stakeholder engagement and ensuring comparability with other studies.

The following criteria were applied to shortlist the indicators into a more manageable number as agreed with stakeholders (Dale & Beyeler, 2001; De Mey *et al*., 2011; Zhen & Routray, 2003).

a) Measurability and availability of data: This refers to how easy or difficult the indicator is for all stakeholders, including farmers, to calculate as well as understand and use.

b) Compatibility with the horticulture production system of the country: This shows the extent to which the indicator is compatible with the farming practice and institutional structure of the farm. This means that the indicators should be perceived by key stakeholders as being relevant to use and implement.

c) Known response to disturbances and anthropogenic stresses as well as changes over time and space: The indicators should be able to predict changes that can be averted by management actions.

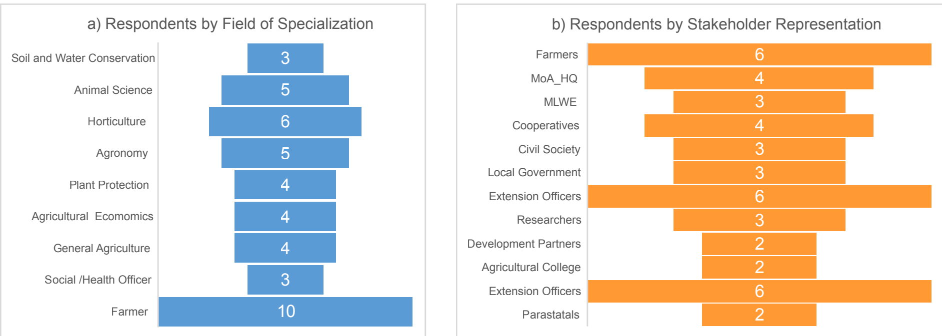
d) Integrative and inclusive: The indicators should be able to measure sustainability in a wide range of farming practices within the horticulture production system (e.g., fruit, vegetable, floriculture and mixed farms).

Using the above criteria, each group prepared a shortlist of indicators through an active discussion among the members. Workshop participants referred to relevant documents and used their knowledge and normative view to set perceived thresholds or critical loads (values) for the indicators by considering a range of specific economic, environmental and social factors.

Ranking of indicators

Based on a stakeholder map prepared during the workshop, 44 respondents were purposively selected to represent the range of stakeholders identified. The representation and specialisation of these respondents are illustrated in Figure 3. Each respondent was asked to rank the 12 shortlisted indicators on a scale from 1 (most important) to 12 (least important) based on their perception and understanding. To ensure clarity and avoid any potential misunderstanding or misinterpretation, clear definitions of each indicator were provided to all respondents prior to ranking. The rankings provided by stakeholders were then consolidated and the total weighted score of each indicator calculated, as shown in figure 6.

Figure 3: Field of specialisation and stakeholder representation of the 44 respondents

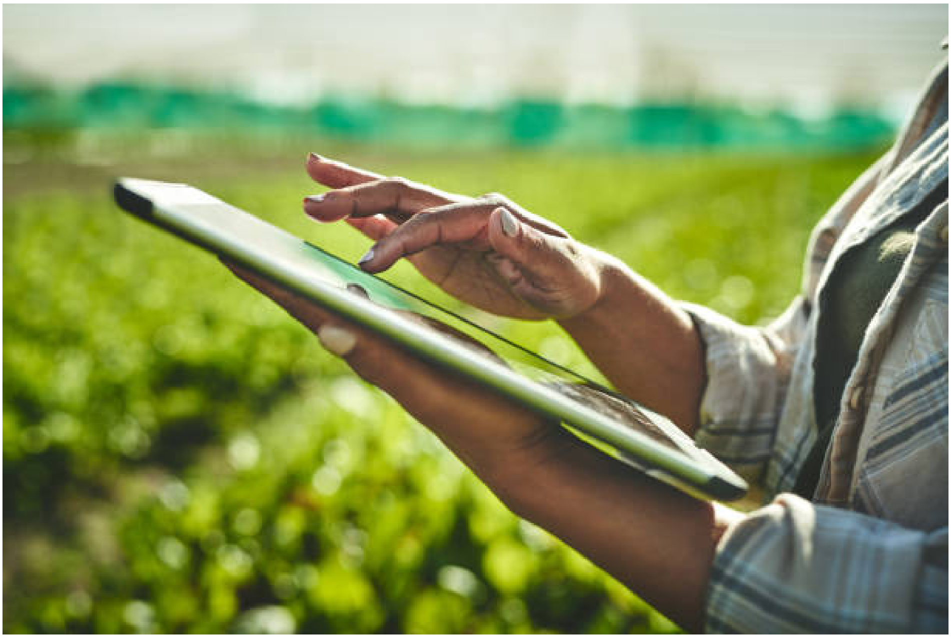


The same respondents were also asked to express their perception of the relative importance of the indicators using a Likert Scale (5 = extremely important; 1 = not important). Means and standard deviations of the ranks were used to see the variability of the choices among respondents and the diversity of their perceptions. Based on the result of the Likert Scale data, the Relative Importance Index (RII) of each indicator was calculated using equation 1, a method commonly employed in ranking attributes based on survey responses (Kometa *et al*., 1994). The RII was computed in addition to the mean scores to facilitate comparison across different indicators and ensure a standardised interpretation of their importance, expressing each indicator's importance relative to the maximum possible value, thereby allowing a better comparative analysis across indicators.

$$RII = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{A*N} \qquad (1)$$

Where n_5 is the number of respondents saying extremely important, n4 saying very important, n3 saying moderately important, n2 saying slightly important and n1 saying not important. A is the highest possible score i.e. 5 and N is the total number of respondents i.e. 44

The respondents were categorised into three major groups: experts (14), extension workers (20) and farmers (10). Their ranking values were averaged and compared for consistency. To analyse the differences in rankings among the three groups, the Kruskal-Wallis H test was used. This non-parametric test is ideal for this study considering the ordinal nature of the data, number of groups compared (>2) and smaller sample size per group where normality cannot be assured. Moreover, Kendall's Coefficient of Concordance (Tau) and Spearman's Rank-order Correlation (rho) were applied to see if there was agreement among the rankings given to the indicators by the main stakeholder groups. While both Kendall's Tau and Spearman's rho measure the same type of association, they can yield slightly different results due to the different ways they handle tied ranks. Kendall's Tau is generally considered more robust to tied ranks, making it a preferred choice when dealing with data that has ties. However, Spearman's rho is

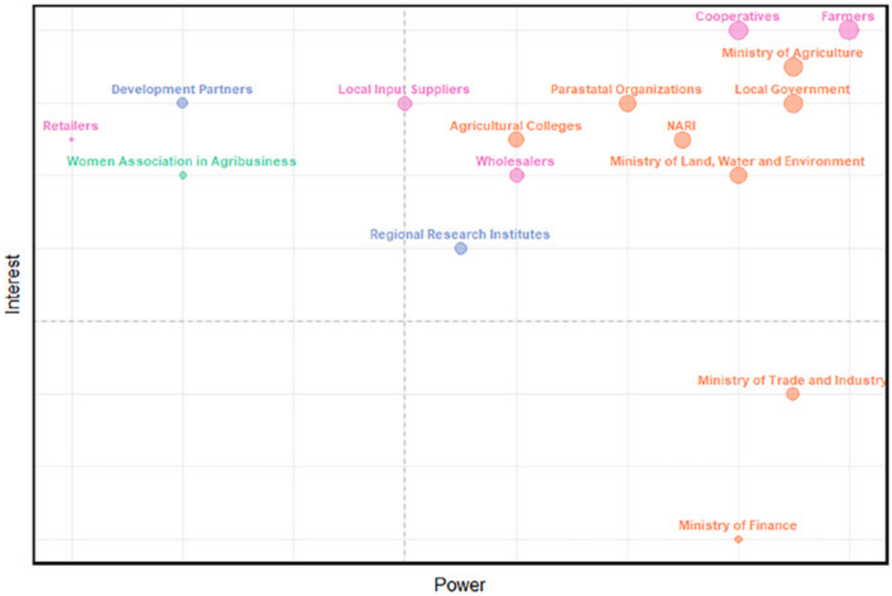


more sensitive to outliers and may be more appropriate when the data is approximately normally distributed (Xu *et al*., 2013) contrary to the opinion of equivalence between SR and KT in some literature, the behaviors of SR and KT are strikingly different in the aspects of bias effect, variance, mean square error (MSE).

Results

Participants first developed a Stakeholders Matrix to categorise key stakeholders in the horticulture production system by their power and interest levels (Figure 4). This visual tool identifies stakeholders with high influence and interest, such as farmers and the Ministry of Agriculture, emphasising their crucial role in sustainability initiatives.

Figure 4: Stakeholder power vs. interest Matrix for horticultural crop production in Eritrea



Colour of stakeholders shows which category they represent (purple: private sector; orange: government bodies; and green: civil society organisations).

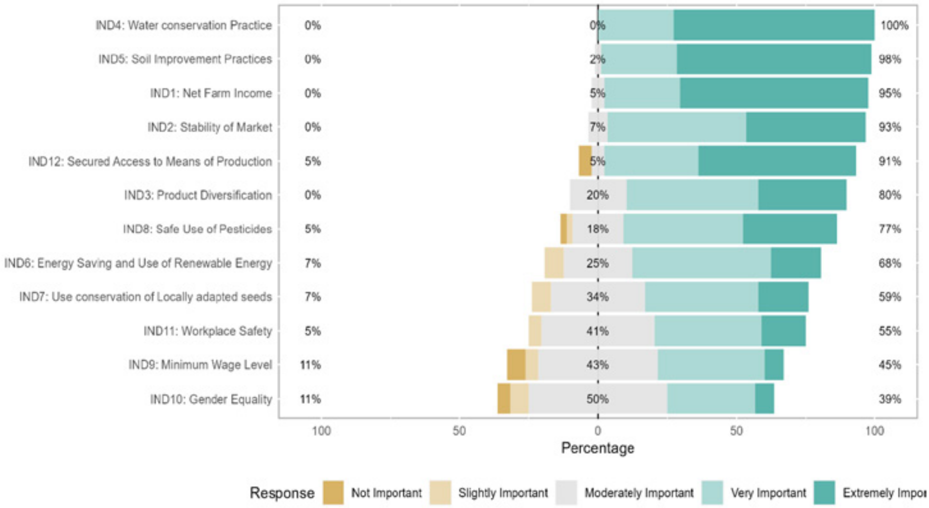
The participants in the national consultative workshop applied the above-mentioned criteria to shortlist the indicators. Indicators chosen twice or more by a group of stakeholders were considered in the final list. Indicators that appeared to be similar were either merged or excluded to avoid redundancy. For example, the indicator Use of Organic Fertilizer is a subset of, and can be merged with, Soil Improvement Practice. The use of renewable energy and energy efficiency can also be merged as one indicator as Energy Efficiency and Use of Renewable Energy.

Accordingly, 12 indicators (three economic, five environmental and four social) were selected in the final list (Table 1) and their ranking is displayed in Figure 3.

Table 1: Final list of indicators and their definitions (FAO, 2013)

Shortlisted Indicator	Definition
Net Income	This indicator measures profitability, financial viability and stability over time after accounting all expenses, including operating costs, depreciations and interest. It measures if the farm is generating sufficient revenue after covering all its costs.
Stability of Market	This is measured by calculating the income structure and determining the number of years the farm has an ongoing business relationship with its major buyer(s) as well as income share per buyer. It also measures financial loss due to unsold products.
Product Diversification	This indicator assesses the diversity of a farm's production by measuring whether it simultaneously generates income from multiple products, encompassing a variety of plants and/or animals.
Water Conservation Practices	This indicator measures the availability of irrigation water over the years and assesses the use of water conservation practices on the farm.
Soil Improvement Practices	This indicator measures the prevalence of using organic fertilizers and if using chemical (synthetic) fertilizers, the adoption of best practices to mitigate the negative impact of chemical fertilizers.
Energy Saving and Use of Renewable Energy	This indicator measures the use of renewable energy sources and application of best practices to reduce energy consumption at the farm level.
Use & Conservation of Locally Adapted Seeds and Varieties	This indicator checks whether the farms save and use locally adapted varieties/seeds that are open pollinating.
Safe Use of Pesticides	This indicator measures the risks and hazards in the use of chemical pesticides and the application of safety measures and best practices.
Minimum Wage Level	This indicator measures if all unskilled labor on the farm earns at least a living wage (or a minimum national wage rate).
Gender Equality	This indicator checks if there is any discrimination in payment, benefits, bonus, workload, scheduling, etc. between men and women working in the same position. It also checks if basic maternity rights (according) to the labour law of Eritrea are respected for all female farm workers.
Workplace Safety	This indicator assesses the implementation of best practices to ensure the well-being and protection of farm employees. It measures whether the farm provides (ensures) a safe, clean and healthy workplace for employees.
Secured Access to Means of Production	This indicator measures whether primary producers have access to the basic "means of production" as expressed in terms of land, water, extension services, training and credit.

Figure 5: Percentage of respondents on the different level of importance of the indicators collected using a Likert Scale



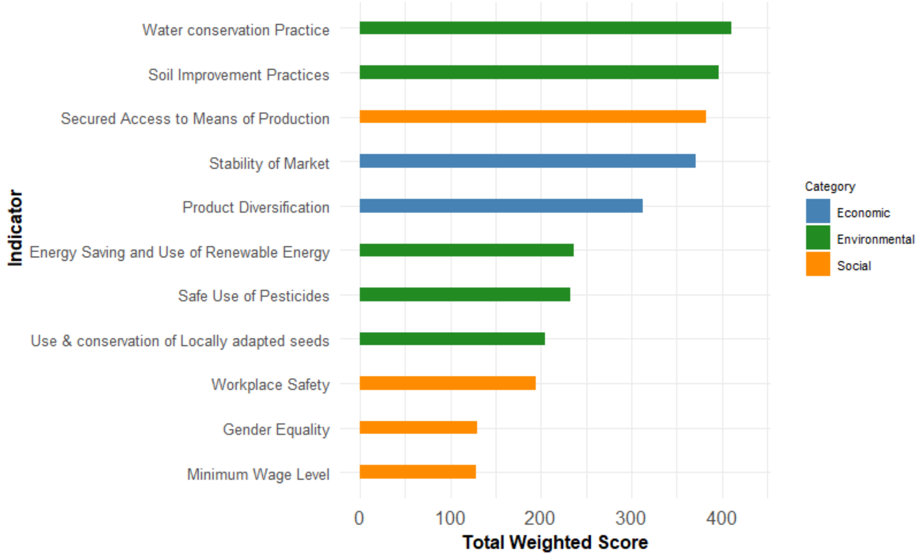
Using the Likert Scale results, mean value and standard deviation was calculated for each indicator. Moreover, the RII of each indicator was calculated as shown in Table 2.

Table 2. Results of the Likert scale showing the mean value, standard deviation and the RII value of each indicator

Indicator	Mean	SD	RII
Net Income	4.64	0.57	0.92
Stability of Market	4.36	0.61	0.87
Product Diversification	4.11	0.72	0.82
Water Conservation Practice	4.73	0.45	0.94
Soil Improvement Practices	4.68	0.51	0.93
Energy Saving and Use of Renewable Energy	3.80	0.82	0.75
Use and Conservation of Locally Adapted Seeds and Varieties	3.70	0.85	0.74
Safe Use of Pesticides	4.05	0.91	0.80
Minimum Wage Level	3.34	0.93	0.66
Gender Equality	3.30	0.87	0.65
Workplace Safety	3.66	0.80	0.73
Secured Access to Means of Production	4.39	0.94	0.87
Weighted Average 4.06			

Following the ordinal ranking of the indicators, the weighted score of each indicator was calculated (Figure 6).

Figure 6: Ranking preference or total weighted score of the indicators



The Kruskal-Wallis H test shows statistically significant differences in the ranking of three indicators i.e. Net Farm Income ($p = 0.019$), Soil Improvement Practices ($p = 0.011$) and Workplace Safety ($p = 0.034$) among the groups. No significant differences were observed for the other indicators, as detailed in Table 3.

Table 3: Mean (SD) values for sustainability indicators across different respondent categories (experts, extension workers and farmers), with Kruskal-Wallis H-statistics and corresponding p-values.

	Experts (n=14) Mean (SD)	Extension workers (n=20) Mean (SD)	Farmers (n=10) Mean (SD)	H-statistic	p-value
Net Income	3.07 (2.23)	4.20 (3.52)	1.30 (0.48)	7.93	0.019*
Stability of Market	5.07 (2.76)	4.75 (2.36)	3.50 (0.85)	2.84	0.244
Product Diversification	6.50 (2.24)	5.85 (2.25)	5.10 (1.79)	2.66	0.264
Water Conservation Practices	3.43 (2.21)	3.60 (1.98)	4.20 (1.40)	1.70	0.428
Soil Improvement Practices	4.07 (1.90)	3.20 (2.19)	5.40 (0.97)	9.04	0.011*
Energy Saving and Use of Renewable Energy	7.57 (2.41)	8.05 (2.87)	6.80 (1.14)	3.11	0.212
Use and Conservation of Locally Adapted Seeds and Varieties	9.14 (2.07)	7.55 (2.24)	8.80 (1.48)	4.74	0.093
Safe Use of Pesticides	7.36 (3.25)	7.15 (2.72)	9.30 (1.06)	5.18	0.075
Minimum Wage Level	9.71 (2.70)	10.25 (2.36)	10.30 (1.83)	0.28	0.868
Gender Equality	9.79 (1.93)	10.00 (2.25)	10.50 (1.08)	0.67	0.716
Workplace Safety	8.07 (3.45)	7.90 (3.16)	10.70 (1.64)	6.77	0.034*
Secured Access to Means of Production	4.21 (3.51)	5.50 (3.61)	2.10 (0.99)	4.81	0.090

Sample sizes for each category are indicated in brackets. Statistically significant differences are marked with an asterisk (*) at $p < 0.05$.

Table 4. Kendall's Tau and Spearman's rho correlation results for correlation between the ranking of the three groups (experts/specialists, extension workers and farmers)

		Correlation coefficient		
		Expert/ specialist	Extension worker	Farmer
Kendall's Tau	Expert/specialist	1.000	0.687**	0.718**
	Extension worker	0.687**	1.000	0.515*
	Farmer	0.718**	0.515*	1.000
Spearman's rho	Expert/specialist	1.000	0.869**	0.869**
	Extension worker	0.869**	1.000	0.755**
	Farmer	0.869**	0.755**	1.000

The correlation of ranking by experts with extension workers and farmers was found to be significant at 0.01 level (2-tailed). This suggests that there is strong evidence to support the existence of a significant positive relationship between the rankings provided by government and academic experts and those provided by extension workers and farmers.

Discussion

The Mendelow's Stakeholder's Matrix result shows that government agencies were placed in the high power, high interest quadrant due to their regulatory authority and resource control. International development partners and regional research institutes, with significant financial resources and technical expertise, were positioned in the medium power, high interest quadrant. Stakeholders like the Farmers' Association, private input suppliers, transportation providers and retailers were placed in the high interest, low power quadrant. This categorisation facilitated strategic prioritisation and engagement of stakeholders. This aligns with other studies using the Stakeholder Matrix method, which find that government bodies and regulatory authorities are typically positioned in the high interest, high power quadrant (Ludovico *et al*., 2020; Reed *et al*., 2009).

Workshop participants excluded those indicators with high data requirements and sophisticated methods as well as indicators not applicable to small-scale horticulture production in Eritrea. For example, participants decided to exclude indicators such as Carbon Footprint, GHG Balance, Intensity of Material Use and Ecosystem Connectivity. Instead, they opted for simple practice-based indicators that could be easily measured and monitored. This aligns with other studies where stakeholders prefer indicators that are easy to measure and straightforward (Luján Soto *et al*., 2020). Accordingly, indicators like Net Farm Income, Stability of Market, Water Conservation Practices and Gender Equality were selected by all groups. This is also shown in case studies conducted in several other African countries, where indicators such as Crop Yield, Land Use and Water Consumption have been commonly used to assess agricultural sustainability nationally (Gebre & Rik, 2017; Yegbemey *et al*., 2014). This is linked to the challenges in gathering complex data and using sophisticated measurement techniques. However, focusing solely on these easily measurable indicators can overlook important aspects of

agricultural sustainability such as biodiversity, soil health and social equity, which are crucial for long-term sustainable development (Bender *et al*., 2016).

Both the Likert Scale and the Ordinal Ranking gave a similar result. Indicators such as Net Farm Income, Water Conservation Practices, Soil Improvement Practices, Secured Access to Means of Production and Stability of Market have got highest preferences among the respondents. Social sustainability indicators gained the lowest rank in both methods. This can be attributed to various factors. Economic indicators are often prioritised as they directly impact the financial well-being and profitability of farmers. This is in line with studies undertaken to assess the adoption behaviour of farmers to new technology or practices in Northern Iran where perceived income was the main driver in the adoption process (Ashoori *et al*., 2019). Other studies also support the tendency of farmers to favour economic indicators when selecting indicators (Latruffe *et al*., 2017; Van Calker *et al*., 2005) .

Scholars like Pretty (2007) strongly recommend use of social indicators and argue that agricultural systems with high levels of social and human assets are more able to innovate in the face of uncertainty. Nonetheless, social indicators are often perceived as less tangible and their measurement can be more complex and subjective compared to economic and environmental indicators (Murphy, 2017; Vivas & Hodbod, 2024).

The standard deviation values provide insights into the variability or dispersion of the responses for each indicator. In this study, indicators related to social sustainability, such as Minimum Wage Level, Gender Equality and Workplace Safety, have higher standard deviation values, suggesting that there is more diversity in the stakeholders' opinions or preferences for these indicators. Research examining farmers' views on social sustainability revealed that the perception of social sustainability is influenced by various factors, including production types (such as dairy, crop and other livestock), farmers' characteristics and awareness (Saleh & Hinrich, 2023). Indicators with values lower than the weighted average indicate a relatively lower level of perceived importance. This means that most of the respondents have a low perception of the importance of most of the social indicators and two of the environmental indicators, namely Energy Saving and the Use of Renewable Energy and the Conservation of Locally Adapted Seeds and Varieties.

Indicators such as Net Farm Income, Water Conservation Practices and Soil Improvement Practices have high RII values of 0.92, 0.94 and 0.93 respectively. The high RII values in conjunction with the mean values indicate a strong consensus among the stakeholders regarding the significance of these indicators. However, it is important to note that while high RII values highlight the priority stakeholders assigned to specific indicators, this does not imply that other indicators, such as Gender Equality or Minimum Wage Level, should be deprioritised. The RII is also highly influenced by the background and expertise area of the respondent. Moreover, the concept of sustainability may have been interpreted differently by various stakeholders, which could have influenced how they assigned higher or lower values to specific indicators.

Comparing the mean ranking results of experts, extension workers and farmers, we observed that farmers prioritise indicators such as Net Farm Income and Access to Means of Production, specifically land and water. This observation is further supported by the results of the Kruskal-Wallis H test, which revealed statistically significant differences in the rankings of Net Farm Income ($p = 0.019$) and Soil Improvement Practices ($p = 0.011$) among the three groups. Farmers consistently ranked Net Farm Income higher, reflecting its critical importance to their livelihoods, while extension workers placed greater emphasis on environmental indicators like Soil Improvement Practices and Water Management Practices. These differences show the prioritisation of each group concerning agricultural sustainability. Farmers, whose daily activities are directly impacted by income and resource access, naturally prioritise economic and access-related indicators. Conversely, extension workers, with their focus on supporting long-term agricultural practices, may prioritise environmental sustainability indicators such as soil and water management. This underscores the importance of collaboration and cooperation among stakeholders. Such collaboration is crucial because it fosters a collective approach to implementing sustainable changes in agricultural systems, promoting knowledge sharing, innovation and resource sharing, which ultimately leads to more effective and impactful solutions for sustainable agriculture (Fraser *et al*., 2006).

Both Kendall's (W) and Spearman's (rho) values for the comparisons between experts and extension workers indicate a high level of agreement. This suggests similar perceptions of

... it is recommended to develop indicators with full and transparent participation from local and national stakeholders.

the indicators' importance by the two groups. However, the relatively lower W value of 0.515 for the comparison between farmers and extension workers suggests a lower level of agreement in their rankings of the indicators. This variance probably emanates from their immediate concerns. Usually, farmers are more concerned with their immediate economic needs by utilising the necessary resources to sustain their livelihoods like using excessive chemical fertilizers to maximize crop yield. Extension workers (mostly hired by the government) advocate for soil improvement practices such as crop rotation and organic fertilizers to protect the long-term health of the soil and prevent environmental degradation. This difference in priorities can lead to a difference in the selection of indicators to assess sustainability. Nonetheless, finding common ground and understanding between the two parties is crucial for the successful execution of sustainable farming practices.

It is expected that the level of agreement or concordance between various groups will vary based on their backgrounds, expertise and roles in the agricultural sector. However, it is important to note that correlation does not imply causation, and the interpretation of Spearman's Rank-order Correlation and Kendall's Coefficient of Concordance should be done in conjunction with other considerations, such as the theoretical relevance of the indicators and the specific goals and objectives of the sustainability assessment.

Conclusion and recommendations

This study aimed to identify and prioritise contextual sustainability indicators for horticultural production systems in Eritrea through a participatory, multi-stakeholder approach. Out of a long list of FAO-SAFA indicators, 12 indicators were deemed to be relevant by all stakeholder groups and feasible for measuring sustainability in the horticulture production system of Eritrea. However, the study revealed differences in the perceived importance of these indicators among the different actors.

These findings suggest that while there is a shared understanding of the overarching goals of sustainability, the pathways to achieving these goals may differ among stakeholders. This underscores the importance of inclusive and participatory approaches in sustainability assessments, where diverse perspectives are integrated to create more comprehensive and applicable frameworks.

The implications of this study extend beyond the context of Eritrea. The methodology used here, grounded in stakeholder engagement and contextual relevance, provides a replicable framework for assessing agricultural sustainability in other developing regions. Future research should continue to refine these indicators, ensuring they remain adaptive to changing environmental and socioeconomic conditions. Policymakers should consider these findings when developing sustainability guidelines for horticulture production in Africa, ensuring that the assessment of sustainability is both inclusive and reflective of local realities. NA94

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Bereket Haile has more than 20 years of experience working on agricultural and rural development projects focusing on environmental and social impact assessment, natural resource management and climate change adaptation. He is currently working on his doctoral dissertation on the Assessment of Sustainability of Agricultural Practices in Eritrea at the Centre for Environmental Studies in the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria (UP).

Professor Andrew Dougill is Dean of the Faculty for the Sciences at York University. He also holds an Extraordinary Professor post at UP's Department of Geography, Geoinformatics and Meteorology. An applied environmental change researcher, his expertise focuses on, among other matters, trans-disciplinary, solutions-focused research projects on environmental sustainability and climate change adaptation.

Professor Abel Ramoelo is a Director of the Centre for Environmental Studies at UP and Associate Professor at UP's Department of Geography, Geoinformatics and Meteorology. He has a PhD in remote sensing from the University of Twente in The Netherlands, worked as an Earth Observation research scientist at the Council for Scientific and Industrial Research (CSIR) and joined South African National Parks (SANParks) in 2018 as a regional ecologist. He serves as a consultant on biodiversity conservation.