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Moving from Productivity to Sustainability in Agricultural Education? Perspectives from Students and Teachers in four African Countries

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Abstract

It is unclear to what extent environmental and social sustainability goals have been included into agricultural education systems, which have traditionally been focused on increasing agricultural productivity. In sub-Saharan Africa, the urgent need to increase productivity while also ensuring environmental and social sustainability has led to significant calls for developing a skill set among the next generation of professionals to meet the Sustainable Development Goals. This exploratory study assesses the perceptions of students and teachers from various universities and vocational agricultural schools regarding the integration of sustainability topics into course curricula based on a survey comprising over 400 students and 300 teachers from four countries in sub-Saharan Africa (Benin, Kenya, Mali, and Nigeria). Using a set of sustainability indicators, this research aimed to uncover the current state and perceptions of sustainability education in agriculture, and whether the necessary conditions are in place for the integration of sustainability into course curricula. The findings revealed that agricultural education in sub-Saharan Africa covers a broad range of topics across environmental, social, and economic dimensions. Additionally, teachers hold advanced degrees on a range of sustainability topics, giving a pool of expertise within agricultural institutions. Nevertheless, the results highlight the need for training to facilitate the mainstreaming of sustainability in course curricula. Challenges hindering the integration of sustainability in course curricula include structural issues such as limited access to relevant course materials, and poor linkages between agricultural education institutions and other stakeholders within the agricultural innovation systems. These barriers highlight the need for an adjustment of the syllabus and the mainstreaming of innovative methods and technologies to better incorporate sustainability into agricultural education. The findings call for policies that apply an innovation systems approach to curriculum design and implementation. This includes fostering stronger connections between educational institutions and the other stakeholders within the agricultural innovation system to enhance the sustainability and impact of agricultural education.

Key Words

Education for Sustainable Agriculture (ESA), Perceptions, Teachers, Students, Sustainability, Agricultural Innovation Systems (AIS), sub-Saharan Africa

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1. Introduction

Agriculture not only plays a key role in ensuring food and nutrition security but also has far-reaching implications for the environment, livelihoods and the society. On the one hand, agriculture is facing challenges such as climate change and variability (Kogo et al., 2021), diseases and pandemics (Jámbor et al., 2020; Rasul, 2021), and local and global crisis, conflicts and instability (Ben Hassen & El Bilali, 2022; Béné, 2020). On the other hand, the agricultural sector is a key driver of climate change, biodiversity loss, soil degradation, and water pollution, among others (DeClerck et al., 2021; Pilling et al., 2020; Raven & Wagner, 2021) and can be associated with an exacerbation of socio-economic inequalities (Clay, 2018; Clay & King, 2019; Vallejos et al., 2022). Consequently, there has been a growing demand for a shift towards sustainable agricultural production (Obach, 2015; Pfeffer, 1992). An important pathway to achieving this outcome is the development of a human resource base with a robust sustainability skill set, ready to address the many challenges the agricultural sector faces (Carlisle et al., 2019).

Previous research has primarily focused on analysing the content of agricultural curriculum (Ataei et al., 2020; Stough et al., 2018; Walsh & Irving, 2024), as well as the drivers shaping the integration of sustainability topics into agricultural curricula (Hilimire et al., 2014; LaCharite, 2016; Tasdemir & Gazo, 2020). Most of these studies have often analysed the perspectives of either students or teachers, and have rarely integrated more than a single case in their analysis (Damico et al., 2022; Diao & Hu, 2022; Nousheen et al., 2020; Yunus et al., 2019). There hasn't been sufficient research on how students and teachers perceive the extent of sustainability coverage in their curricula, particularly in the context of Africa. Students' and teachers' perspectives matter because their experiences, attitudes, and perceptions play a crucial role in the success of sustainability education. Their input can guide improvements in curriculum design and delivery. Furthermore, understanding how sustainability is perceived and experienced by students and teachers can lead to more effective pedagogical approaches (Rehman et al., 2023; Valley et al., 2018), and guide improvements in curriculum design and delivery (Chinedu et al., 2023; Fekih Zguir et al., 2022). Furthermore, students' views can enhance learning outcomes, engagement, and the application of sustainability principles in real-world contexts. Lastly, the integration of sustainability principles may impact their career decisions and their prospects for employment after completing their training (Kaki et al., 2022).

This study therefore aims at exploring teachers' and students' perceptions on the coverage of sustainability topics in course curricula. In so doing it seeks to answer the following questions: 1) To what extent is sustainability embedded in course curriculum? 2) What are

the challenges and opportunities for integrating sustainability curriculum in agricultural education and training? 3) What are the structural and institutional conditions shaping the implementation of agricultural curriculum? The study relies on a survey of teachers and students from a broad range of Agricultural Technical and Vocational Education and Training (ATVET henceforth) institutions in four countries in sub-Saharan Africa (Benin, Kenya, Mali, Nigeria). The selection of these countries is motivated by the slow pace of agricultural education in sub-Saharan Africa. A review by Kirui & Kozicka (2018) of ATVET programs in selected sub-Saharan African countries reveals a significant shortage of training opportunities, and highlights the gap between the skills supplied in ATVET institutions and the needs of the private sector and local administrations. Kirui & Kozicka (2018) also observe that ATVET programs primarily focus on production skills and target producers, at the expense of other aspects, including practical training. This regional focus will offer new insights into the current state of ATVET and the extent to which it departs from its primary focus on production. As the continent continues to grapple with challenges related food security, ensuring that the development and growth of the agricultural sector is achieved without jeopardising the sustainability of the environment or social equity, will require strategies for skills development for sustainable agriculture.

2. Insights from the literature

Education for sustainable development (ESD) has been high on the agenda in the past few years. International organizations, including United Nations bodies such as the United Nations Educational, Scientific and Cultural Organization have been instrumental in formulating policies and frameworks that guide countries in incorporating sustainability into their education programs (UNESCO, 2020). More than fifteen years ago, the 'Bonn Declaration' (2009) had already highlighted the importance of acknowledging and incorporating sustainability incorporating sustainability in education. ESD can help to ensure sustainability-literate professionals, which can effectively make informed choices and engage in actions that align with environmental, social, and economic sustainability (Carlisle et al., 2019; Charatsari & Lioutas, 2019; Chinedu et al., 2023). Sustainability-literate professionals possess competencies that prepare them for responsible behaviours and attitudes (Charatsari & Lioutas, 2019; Francis et al., 2017; Nyamweru et al., 2023; Probst et al., 2019). In the case of agriculture, this is instrumental in driving sustainable agriculture (Durán Gabela et al., 2022; Eugenio-Gozalbo et al., 2021). Scholars have emphasized that innovations in agricultural education can have multifaceted benefits, including building livelihoods resilience, addressing food security, and promoting environmental protection and economic development (Dooley & Grady Roberts, 2020; Ibrahim, 2023).

Despite these significant opportunities, it was proven that students often have a limited understanding of the concept of sustainability (Alibaygi & Pouya, 2011; Damico et al., 2022; Tasdemir & Gazo, 2020). Consequently, students often encounter challenges in accurately defining sustainable agriculture and may struggle to grasp fundamental sustainable agricultural practices (Sitienei & Morrish, 2014). In a study of 1063 students of one University in Argentina, which included 321 agricultural students, Damico et al. (2022) have found that only 10% had a full conception of sustainability, and were able to identify all three sustainability dimensions. Moreover, the majority of these individuals acquired this comprehensive knowledge outside of their university courses. To address this gap, there has been a push for the implementation of sustainability-sensitive curricula aimed at enhancing students' comprehension of sustainable agricultural practices (Dooley & Grady Roberts, 2020; Hilimire et al., 2014; Nyamweru et al., 2023; Valley et al., 2018).

The outcomes of sustainability education depend on how the course curriculum is designed and executed (Baptista et al., 2021; Monavvarifard & Alibaygi, 2023; Tasdemir & Gazo, 2020). Studies have highlighted that course contents often lack the inclusion of all sustainability principles (Biasutti et al., 2016; Sitienei & Morrish, 2014) or are outdated and fail to reflect current realities (Nikšić et al., 2023). Jabbour & Pellissier (2019), for example, highlight instructors' perspectives on the difficulties posed by the shortage of subject-specific teaching materials. Additionally, the slow uptake of Education for Sustainable Development (ESD) in ATVET curricula may be attributed to the complexity and a lack of a clear understanding of the concept itself (Žalėnienė & Pereira, 2021). ATVET institutions may still grapple with understanding how best to integrate sustainability into their curricula (Allen et al., 1991; Greig & Priddle, 2019; Stough et al., 2018). In light of these challenges, there has been a growing demand for a re-evaluation of curriculum content to ensure that education is more effectively tailored toward sustainable agriculture (Rehman et al., 2023). In their study of best practices in sustainable agriculture education, Baptista et al. (2021) have argued that MSc programmes should emphasise interdisciplinary learning and cover topics that encompass both adaptation and mitigation strategies, akin to those employed in the Circular Economy approach. In a similar study on agricultural curriculum practices within Southern Europe's Balkan region, Koulaouzides et al. (2003) have discovered that students' comprehension of sustainability concepts significantly improves when courses are purposefully designed to enhance environmental awareness, facilitate the acquisition of multidisciplinary knowledge, and incorporate practical applications of information technology. Ensuring that students grasp the complexities of agricultural decision-making is vital for preparing them for careers in agricultural sustainability (Basche & Carter, 2021).

Achieving this goal will necessitate significant innovations in the teaching methods used in higher education and ATVET institutions for sustainability training (Monavvarifard &

Alibaygi, 2023). Including practical components, which allows students to apply the practices they have learned, has the capacity to enhance the learning experience and cultivate favourable attitudes and behaviours in relation to sustainable agriculture (Durán Gabela et al., 2022; Eugenio-Gozalbo et al., 2021; LaCharite, 2016; Valley et al., 2018). This comprehensive approach serves the dual purpose of ensuring the thorough assimilation of course material and the subsequent translation of acquired principles and concepts into practical implementation. Valley et al. (2018) have advocated for a pedagogical framework that nurtures experiential learning and cultivates systems thinking in the education of agricultural and food systems. This strategy has proven to be successful in some settings. For example, Eugenio-Gozalbo et al. (2021) have observed that the students in universities in Spain, where gardens are implemented for hands-on experience, exhibited greater awareness regarding the environmental effects of agriculture, and improved waste management practices when given the opportunity to learn through practice. The same outcome have been observed by Nyamweru et al. (2023) in their study of students in agricultural vocational schools in Burundi, and concluded that engaging in educational agricultural activities significantly impacts students' connection to their immediate environment and their perceptions of how agriculture affects their local community. These findings underscore the notion that sustainability education plays an important role in cultivating positive attitudes towards sustainable agriculture (Durán Gabela et al., 2022). While previous literature has explored the importance of sustainability in ATVET curricula, most studies have limited their analysis to either students or teachers, and often focused on single countries. There is a lack of comparative research that examines sustainability curricula across multiple countries, which could provide a broader understanding of its impact and effectiveness. Additionally, previous studies have often overlooked examining the environmental and structural conditions, instead concentrating on offering recommendations for what the structural and institutional environment should be like. These gaps highlight the need for research that compares teachers' and students' perceptions concurrently, and explores the curriculum environment, to better understand their impact on sustainability curricula and tailor more evidence-based recommendations.

3. Methodology

3.1. Site description

This study was conducted as part of a collaborative program involving a consortium of African and German research organizations, known as the "Program of Accompanying Research for Agricultural Innovation" (PARI). This joint initiative was funded by the German Federal Ministry for Economic Cooperation and Development (BMZ). The research was

carried out in Benin, Kenya, Nigeria, and Mali. Table 1 provides a brief description of the agricultural sector and educational landscapes in the selected countries.

Table 1. Selected countries' profiles

	Benin	Kenya	Mali	Nigeria	Data source
Agriculture contribution to GDP (%)	26.9	21.2	36.4	23.7	<i>(World Bank Open data, 2023)</i>
Employment in agriculture (%) *	28.1	33	68	38	<i>(World Bank Open data, 2023)</i>
Government expenditure on education (% of GDP)	3.2	4.1	4	3.1	<i>(World Bank Open data, 2023)</i>
Youth literacy rate (% of 15 to 24 years old)	66	89	46	75	<i>(World Bank Open data, 2023)</i>
Number of institutions	3 universities, 4 technical institutes	10 universities, 3 technical institutes	1 university, 5 technical institutes, 1 polytechnic institute	26 university, 37 technical institutes, 5 polytechnic institute	2023, AET

Source: Authors. * Percentage of total employment

Agriculture holds a prominent role in each of the four countries, contributing substantially to their Gross Domestic Product (GDP), and serving as the primary source of employment. In all countries, more than 20% of total GDP is accounted for by the agricultural sector (36 % in Mali), and over a quarter of the population is employed in agriculture (reaching 68% in Mali). Youth literacy rates vary across countries, with Mali exhibiting the lowest rate (46%), and Kenya the highest (89%). While all countries have ratified the SDGs, including SDG4, which emphasises the provision of quality education, current expenditures on education fall short of the 15 to 20% benchmark agreed upon by UNESCO Member States in 2015.

Table 2. List of ATVET institutions in selected countries

	Benin	Kenya	Mali	Nigeria
Institutions	<ul style="list-style-type: none"> -Université d' Abomey-Calavi (FSA), -Université de Kétou -Université de Parakou (FA), -Lycée Agricole de Adja-Ouèrè (dep. Plateau), -Lycée technique agro-pastoral de Kpataba (Savalou), -Lycée Agricole Médji de Sékou -Lycée Agricole de N dali -Lycée Agricole de Natitingou, -Lycée Agricole de Kika, -Lycée Agricole de Akodéha (dep. Mono), -Lycée technique agricole d'Adjahonmey -Songhai Center, -Centre de formation Liweitari -Sirarou training center -Collège privé de formation technique Agricole -KOBERSIDE International : CPETAK -Unité de Recherche et de Formation en Machinisme Agricole de Niaouli -DEDRAS 	<ul style="list-style-type: none"> -Animal Health & Industrial Training Institute (AHITI) Kabete -Animal Health & Industrial Training Institute (AHITI) Ndomba -Baraka Agricultural College (private) -Bukura Agricultural College (public) -Dairy Training School (DTI) -Kaiboi Technical Training Institute -Rift Valley Institute of Science and Technology (RVIST) (public) (Nakuru) -Kenya YMCA College of Agriculture and Technology -Katine Technical Training Institute -Karen Technical Training Institute for the Deaf -Eldoret Technical Training Institute (public) -Eldoret College of Professional Studies -The Nyeri National Polytechnic -University of Nairobi (UoN) -Egerton University -Jomo Kenyatta University of Agriculture and Technology (JKUAT) -Eldoret University (Eou) 	<ul style="list-style-type: none"> -Institut Polytechnique de Formation et de recherche Appliquée de Katibougou (Koulikoro) -Institut de Formation Professionnelle -Agronomie- Université de Ségou -Centre de Formation Agro-pastoral de Bamako -Centre Agro-pastoral de Ségou -Centre de Formation Professionnelle pour la Promotion de l'Agriculture au Sahel de Gao -Centre de Formation Polytechnique Rurale de Kita -Centre de Formation Pratique en Elevage de Sotuba -Centre Formation en Foresterie de Tabakoro -Institut de Formation Professionnelle Malick Sidibe -Centre d'Apprentissage Agricole de Same (Kayes) -Centre d'Apprentissage Agricole de Samanko (Koulikoro) -Centre d'Apprentissage Agricole de M'pessoba (Sikasso) -Centre d'Apprentissage Agricole de Dioro (Ségou) -Centre d'Apprentissage Agricole de Kita (Kayes) -Université Bazo de Bamako -Ecole des Infirmiers Vétérinaires de Sotuba -Kone Grilles-Ecole Secondaire Agropastorale ESAP -Champs-Ecoles de la FAO -Kairaso, Ecole de l'agriculture durable au sahel -Les Centres d'animation rurale (CAR) -Institut de Formation en Genie Rural -Ecole Agro-Pastorale de Paul Diallo -Ecole Agro-Pastorale de Blaise Pascale -Ecole Agro-Pastorale Cite Verte -Ecole Agro-Pastorale Momo -Ecole Agro-Pastorale Fadiala Coulibaly -Institut de Génie Rural -Complexe Agro-Pastoral Fatoumata Coulibaly -Complexe Agro-Pastoral Mamadou Moussa Kone -Ecole Agro-Pastorale de Wayerma -Complexe Agro-Pastoral Salama -Complexe Agro-Pastoral Binta Diaby 	<ul style="list-style-type: none"> -Akperan Orshi College of Agriculture -Audu Bako College of Agriculture -Bauchi State College of Agriculture -College of Agriculture and Animal Health -College of Agriculture and Animal Science -College of Agriculture, Jalingo -College of Agriculture, Kabba, Kogi State -College of Agriculture, Zuru, Kebbi State -Edo State College of Agriculture, Edo State -Federal College of Agriculture, Akure, Ondo State -Federal College of Agriculture, Moor Plantation, Ibadan, -Federal College of Agriculture, Ishiagu, Ebonyi State -Federal College of Agricultural Produce Technology, Kano -Federal College of Animal Health & Production Technology, Ibadan -Federal College of Animal Health & Production Technology, Kaduna State -Federal College of Fisheries & Marine Technology, Victoria Island -Federal College of Forestry, Ibadan, Oyo State -Federal College of Forestry, Jos, -Federal College of Forestry Mechanisation, Afaka -Federal College of Forestry Resources Management, Fugar, Edo State -Federal College of Forestry Resources Management, Ishiagu, Ebonyi State -Federal College of Forestry Resources Management, Maiduguri, Borno State -Federal College of Freshwater Fisheries Technology, Baga, -Federal College of Freshwater Fisheries Technology, New Bussa, -Federal College of Horticultural Technology, Dadin Kowa, Gombe State -Federal College of Land Resources Technology, Kuru, -Federal College of Land Resources Technology, -Federal College of Wildlife Management, New Bussa, Niger State. -Federal College of Veterinary and Medical Laboratory Technology, Kaduna Polytechnic, Kaduna -Mohammed Lawan College of Agriculture, Maiduguri, Borno State -Niger State College of Agriculture, Mokwa, Niger State. -Plateau State College of Agriculture, Garkawa, -Samaru College of Agriculture, DAC ABU, Zaria, Kaduna State. -Yobe State College of Agriculture, Gujba -Oyo State College of Agriculture and Technology

Source: Authors

The agricultural education landscape comprises public and private institutions that provide informal training and formal education at secondary and tertiary levels. In all countries, professionals for the agricultural sector are trained through public and private institutions, and complete their curricula with either a certificate or a diploma offered respectively by universities and technical and vocational schools. Several specialized agricultural institutions and universities are involved in skills development in agriculture. In Mali, the "National Policy for Vocational Training" includes a component dedicated to promoting vocational training in agriculture. In Benin, efforts are made to equip the country with 25 vocational schools dedicated to agricultural education by horizon 2025. To this end, collaborations with institutions in Europe have been established. In the same vein, national strategies for agricultural education are designed in Kenya, with partners such as GIZ, to reform vocational education in agriculture and boost the sector. In Nigeria, the National Policy on Education provides a framework that includes agricultural vocational training. ATVET is provided by a variety of Federal and State Colleges of Agriculture, as well as vocational and innovative enterprises, alongside private initiatives.

3.2. Sampling methods and data analysis

The study employed a survey design to collect data from a sample of students and teachers/lecturers from vocational schools, technical colleges and universities. Table 3 lists the institutions included in the study, and Table 4 describes the sample distribution in each country.

Table 3. List of sampled institutions

	Benin	Kenya	Mali	Nigeria
Institutions	-Lycée Agricole Médji de Sékou -Lycée Agricole de Ndali -University Parakou - Centre Songhai	-Baraka Agricultural College -Bukura Agricultural College -Egerton University -Eldoret University	-Institut Polytechnique de Formation et de recherche Appliquée de Katibougou -Université de Ségou -Centre d'Apprentissage Agricole de Samanko -Centre d'Apprentissage Agricole de M'pessoba -Ecole Agro-Pastorale de Paul Diallo -Ecole Agro-Pastorale de Blaise Pascale	-Kaduna Polytechnic -Samaru College of Agriculture - Federal College of Agriculture, Moor plantation, Ibadan -Oyo State College of Agriculture and Technology

Source: Authors

Table 4. Sample size distribution

Country	Survey sample	
	Students	Teachers
Benin	100	102
Kenya	96	56
Mali	108	83
Nigeria	110	98
Total	414	339

Source: Authors

Data were collected following a multi-stage sampling approach. First, an exhaustive list of all agricultural vocational and technical schools, as well as universities in each country, was compiled. With the assistance of experts from each country, four to six institutions were selected based on criteria such as geographical location, safety, and institutional characteristics (vocational school or university). A total of 18 vocational and tertiary level education institutions were included in the study (see Table 3). The next stage consisted in the sampling of students and teachers from the selected institutions. The study strategically prioritized students in their final year of their academic program, to capture insights from individuals that have gone through the whole curriculum in their respective programs. Around 100 students were randomly sampled from the list of final years across different programs, totalling 414 respondents for this study. Similarly, 339 staff members were randomly selected from a comprehensive list of teaching staff in each of the selected universities and vocational schools. Informed consent was obtained from all respondents.

The surveys included inquiries into demographic characteristics, perceptions about sustainability, and the integration of sustainability issues into course curricula. To explore how well sustainability is integrated into the course curriculum, we asked questions about key indicators along each dimension of sustainability (see Table 5). We surveyed students to determine whether these topics were covered in their curriculum, and teachers were asked about their inclusion of these topics in their teaching materials.

Table 5. Sustainability indicators in ATVET survey

	SUSTAINABILITY DIMENSIONS		
	Economic	Environmental	Social
Indicators	<ul style="list-style-type: none">• Productivity• Marketing and commercialisation• Microfinance	<ul style="list-style-type: none">• Climate change• Efficient use of inputs (Fertilisers, pesticides, etc.)• Safe handling of agro-chemicals• Soil management• Water management• Biodiversity• Animal health	<ul style="list-style-type: none">• Gender equity• Nutrition• Marginalised groups

Source: Authors

The survey findings are derived from a descriptive analysis of the data conducted using STATA14. For clarity and comparative purposes, analyses were conducted separately for students and teachers.

4. Results

4.1. Characteristics of staff and students and their sustainability attitudes

4.1.1. Demographic and professional profiles of ATVET staff

Table 6 describes the backgrounds of ATVET teachers. The analysis highlighted a diversity of socio-economic characteristics across and within countries.

Table 6. Demographic and professional backgrounds among ATVET staff by country

Respondents' characteristics	ATVET Staff				
	Benin	Kenya	Mali	Nigeria	All
Female (%)	12	30	8	23	19
Age below 40 years (%)	71	32	52	38	48
Origin in rural areas (%)	61	95	63	51	67
MSc or PhD (%)	50	52	67	72	60
Studied abroad (%)	28	9	42	8	22
Professional background					
Crops & horticulture	66	34	36	8	36
Livestock & aquaculture	11	36	14	13	19
Social sciences	3	9	19	21	13
Technology	6	5	7	33	13
Environmental sciences	7	2	10	6	6
Extension & comm.	1	7	1	11	5
Business & management	2	5	5	3	4
Health & nutrition	0	0	0	0	0
Others	5	2	7	4	5

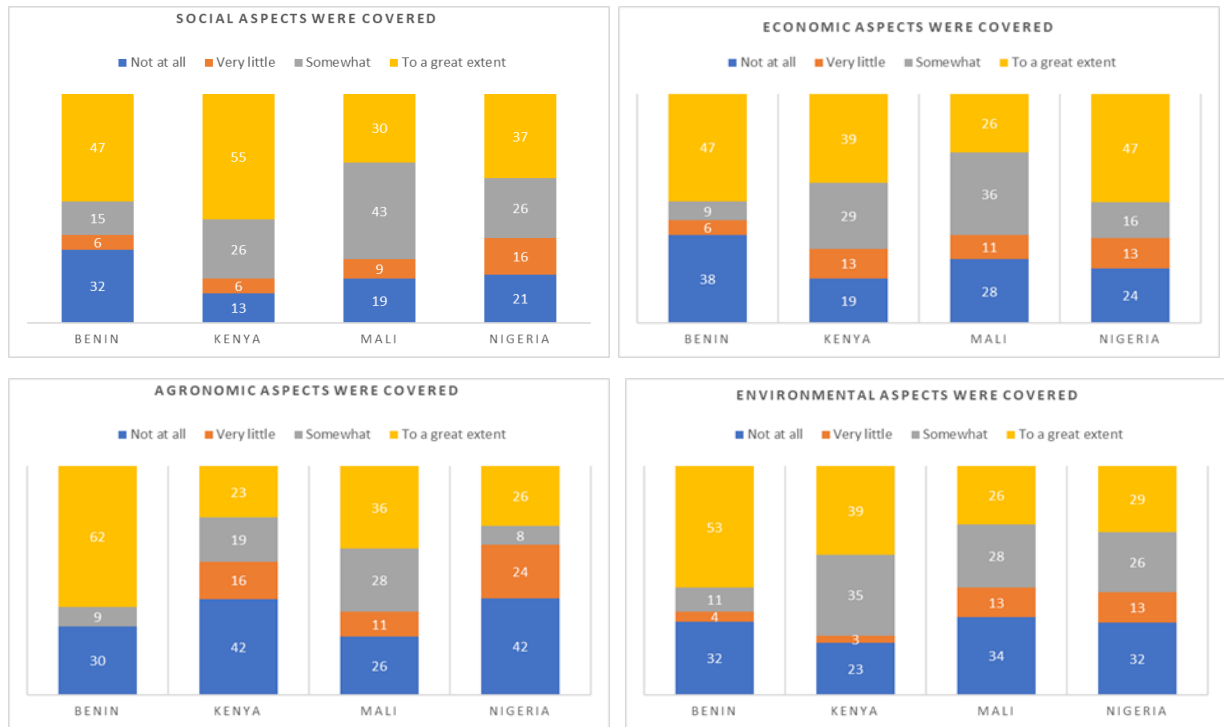
Source: Authors

In Benin and Mali, most staff members are younger than 40, while in Kenya and Nigeria, the majority of staff respondents are older than 40. Across all four countries, a considerable proportion of the staff interviewed come from rural areas. There is also a notable gender disparity among ATVET staff, with the percentage of female staff differing significantly between countries, with the lowest share observed in Mali, while the largest proportion of female staff is found in Kenya. Overall, across all countries, the percentage of women relative to male staff members remain low.

In terms of educational qualifications, many ATVET staff members across all countries hold advanced degrees, such as Master of Science or Doctor of Philosophy. The academic staff includes teachers and lecturers with diverse backgrounds and expertise. Staff specializing in crops and horticulture make up a significant portion across all countries. Social sciences also contribute to the diverse composition of ATVET staff. Additionally, expertise in technology is represented among ATVET staff, with Nigeria having the highest share in this category. While the ATVET staff exhibit a broad spectrum of expertise, some areas are less represented. Staff members with a background in environmental sciences, extension and communication, and Business & Management are present, but in smaller proportions. None of the surveyed teachers or lecturers reported having backgrounds in nutrition and health.

In addition to primary academic backgrounds, over 55% of ATVET staff responded that they underwent trainings in the past five years. Figure 1 illustrates their responses on the extent of coverage of economic, environmental or social topics in these trainings.

Figure 1. Additional Training Topics Pursued by ATVET teachers (% of respondents)



Source: Authors

Overall, while there were variations in the responses, the analysis revealed that supplementary trainings in the surveyed countries generally addressed economic, environmental, social, and agronomic aspects to some degree. Economic and social aspects were generally covered from a moderate to high extent, with Benin and Nigeria showing higher proportions of extensive coverage. ATVET staff provided diverse perspectives regarding the inclusion of environmental aspects in the trainings they attended. Specifically, the majority of respondents from Benin and Kenya reported that the topic was extensively covered compared to those from Mali and Nigeria. The answers on the attention given to agronomic aspects in trainings attended showed mixed results, with significant proportions of respondents in Kenya and Nigeria reporting little to no coverage, while most respondents in Benin reported that this topic was covered to a great extent.

4.1.2. Students characteristics and motivations

Table 7 and Table 8 show the demographic characteristics and career aspirations of ATVET students across all four countries. The results highlighted a diversity of backgrounds and preferences in the sample.

Table 7. Characteristics of ATVET students in selected countries

	Benin	Kenya	Mali	Nigeria	All
Gender (share of females) %	36	39	35	46	39
Age	21	22	24	24	23
Origin (share rural) (%)	59	96	56	47	64
Origin (share farming) (%)	33	97	69	71	67
Own cultivation (share yes) (%)	31	71	35	47	46

Source: Authors

Gender distribution shows slight differences, with Nigeria having the highest percentage of females compared to other countries. The age of students ranges from 21 to 24, with an average age of 23 across all four countries. Socio-demographic characteristics vary among countries, but the majority of students come from rural areas and farming backgrounds, with Kenya having the highest proportion. Additionally, a notable proportion of students own and cultivate their own farms, with this being more common in Kenya.

Table 8. Students' career aspirations following graduation

		Benin	Kenya	Mali	Nigeria	All
Career plan after graduation (%)	<i>Agro-entrepreneur</i>	49	16	34	37	34
	<i>Private, public, or third-sector extension service</i>	23	51	33	21	32
	<i>Agricultural Research Institutes and Academia</i>	8	7	24	17	14
	<i>Ministry of Agriculture (and similar)</i>	0	13	6	11	7
	<i>Independent consultants</i>	5	6	1	9	5
	<i>Others</i>	15	7	1	5	7

Source: Authors

Table 8 highlights disparities in students' preferences regarding their future career paths. The highest proportion of students aspire to become agro-entrepreneurs, with this aspiration being particularly common in Benin. Similarly, a significant number of students are interested in roles within private, public, or third-sector extension services, especially in Kenya. Interest in working within the Ministry of Agriculture was comparatively low, and in Benin none of the surveyed students expressed interest in this career path.

4.1.3. Awareness and attitudes towards sustainable agriculture

Table 9 outlines students' perceptions of the major challenges facing the agricultural sector. The top three constraints identified are climate change, input costs, and soil fertility, each recognized by a significant portion of students. The most commonly perceived constraints to agriculture fall within the environmental realm, with an average of 39% of respondents highlighting challenges in this category, particularly related to climate change and soil

fertility. Climate change were particularly pressing for students in Kenya and Mali, where more than half of respondents highlighted the issue. Similarly, a high proportion of students in Benin and Mali considered that soil fertility was a major concern for farmers. The economic dimension received less attention compared to environment-related aspects, though variations were observed across countries. While students from Benin, Kenya, and Mali mentioned economic concerns relatively less, an important proportion in Nigeria highlighted issues related to access to finance and marketing as significant problems for farmers. Conversely, challenges falling under the social category were highlighted by about 20% of respondents, presenting a smaller focus compared to the economic and environmental dimensions. In the survey responses, none of the survey respondents raised issues related to gender equity, the inclusion of marginalized groups, or health and nutrition. Concerns were particularly identified in terms of farmers education, land tenure issues or access to adequate extension services and digital tools.

Table 9. Students’ perceptions of challenges faced by farmers

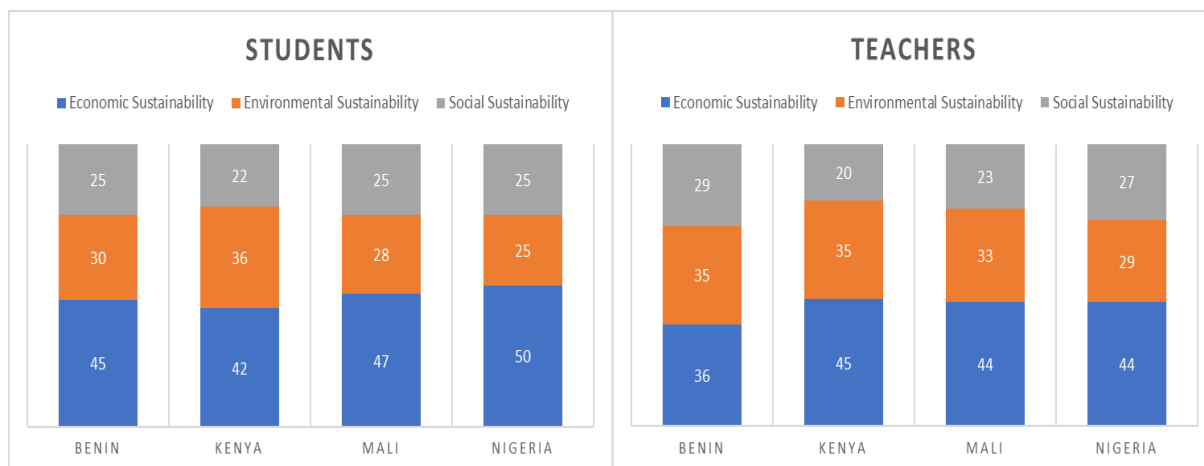
Sustainability dimension	Farming Challenges	Benin	Kenya	Mali	Nigeria	All
Environment	Soil fertility	49	35	69	32	46
	Changing climatic patterns	25	77	51	32	46
	Water	34	15	40	20	27
Socio-Economic	Availability and cost of inputs	22	41	78	42	46
	Finance (e.g., access to credit/savings, etc....)	21	38	23	52	34
	Marketing / commercialization	15	30	31	49	32
	Poverty and inequality	8	28	34	41	28
	Education	25	34	23	23	26
	Funding (e.g., for research and development, education, rural infrastructure etc....)	9	23	31	32	24
	Extension service	0	43	6	30	20
	Use of digital tools	16	15	19	24	18
	Rural infrastructure	7	11	26	26	18
	Lack of modern work tool	5	6	7	1	5
	Low mechanization	5	3	5	4	4
	Land tenure	0	1	3	8	3

Source: Authors

In a hypothetical scenario, teachers and students were asked their preferred allocation of agricultural budget among different dimensions of sustainability. Figure 2 indicates that both teachers and students prioritize economic sustainability, as evidenced by relatively high percentages allocated across countries, more than 40% in both cases. Although nearly 50% of the remaining budget is allocated to environmental and social issues, notable differences are observed between the responses of teachers and students. Specifically, in all four

countries, teachers allocate over two-thirds of the remaining budget to environmental issues. As for students, the observed trend is to allocate a larger share to social aspects.

Figure 2. Students’ and Teachers’ perspectives on the “ideal” agricultural budget allocation (%)



Source: Authors

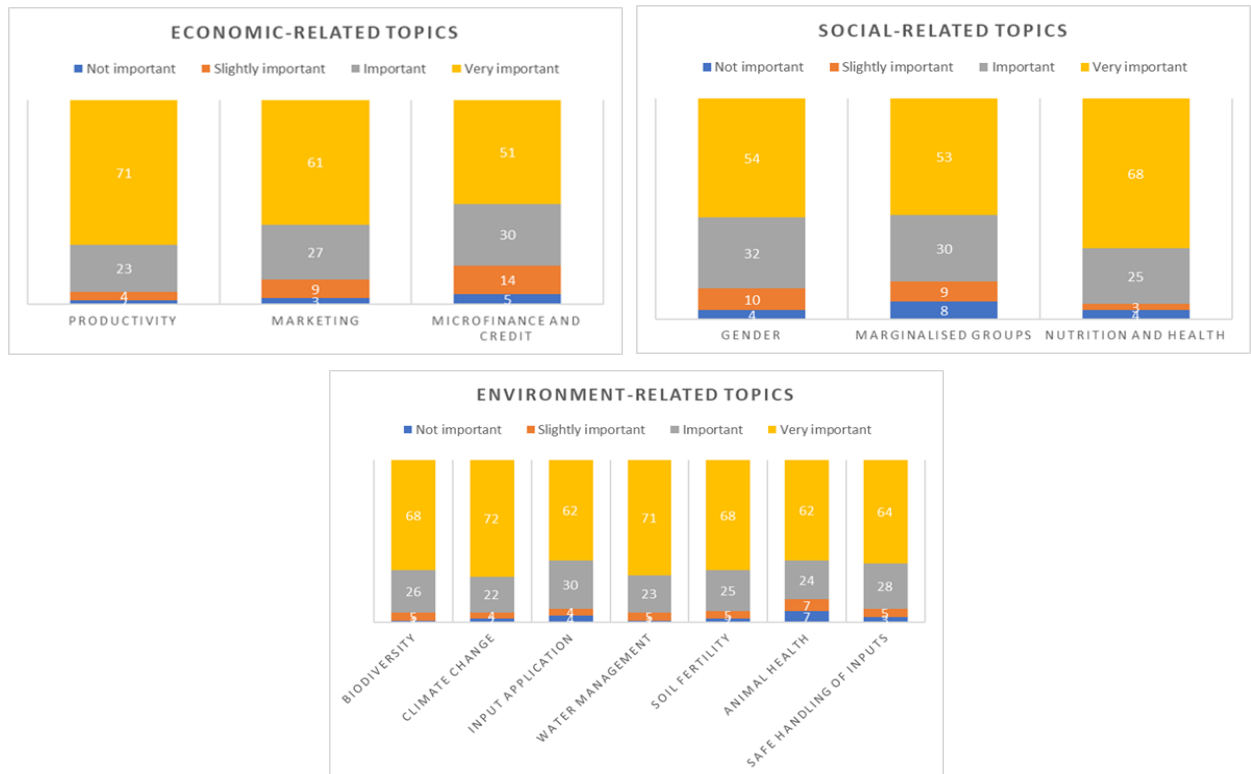
4.2. Sustainability in ATVET curriculum

The following statistics reflect teachers’ and students’ perspectives on the content of curriculum in ATVET programs. The results stem from their responses to questions assessing their level of agreement with statements pertaining to the inclusion of economic, environmental and social topics in the course curriculum.

4.2.1. Teachers’ perspectives on curriculum content

Figure 3 provides insights into how teachers across all four countries view the incorporation of sustainability topics into ATVET curricula, revealing nuanced perspectives across multiple dimensions.

Figure 3. Teachers' perspectives on the importance of specific topics by sustainability dimension (% of respondents)



Source: Authors. Note: “As part of the teaching how important is ...?”

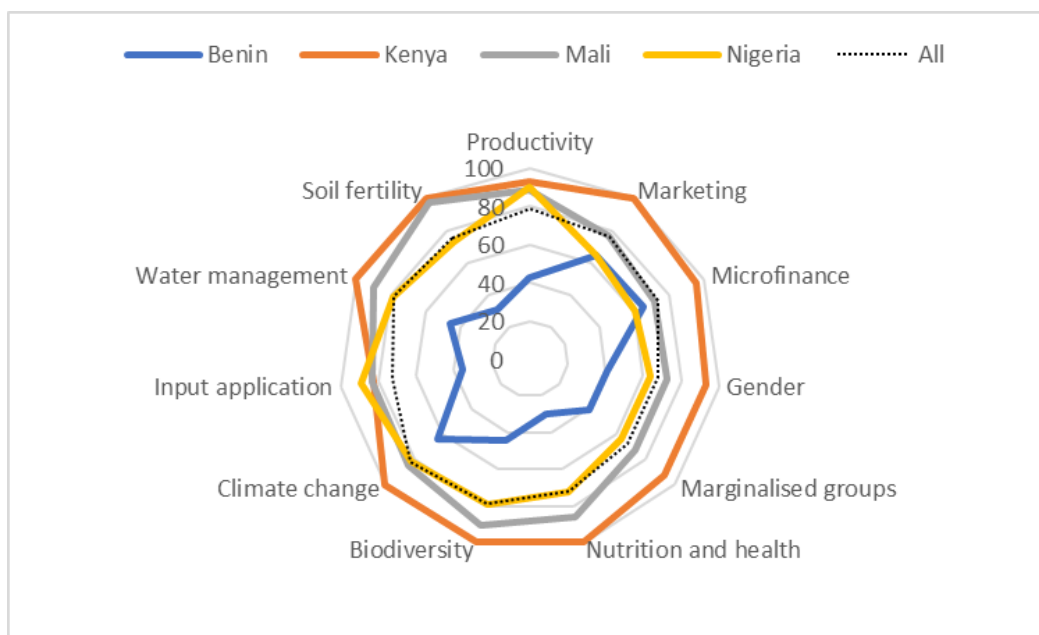
The economic dimension provides insights into respondents' perspectives on productivity, commercialization/marketing, and microfinance and credit within ATVET curricula. A significant majority of respondents consider productivity issues as a fundamental aspect of the overall curricula. Commercialization/marketing topics follow a similar trend, although a lower proportion view them as crucial, indicating a slightly less unanimous consensus on their importance. Microfinance and credit, while still deemed important by a majority, elicit varied responses, with a notable proportion acknowledging their importance in the course curriculum.

Regarding social topics, gender emerges as critical, with a significant majority considering it a fundamental aspect of teaching. Similarly, topics addressing marginalized groups are widely recognized as occupying an important place in teaching content. However, nutrition and health receive somewhat different responses, with a majority considering them important, although a sizable proportion still views them as very important.

In the environmental dimension, biodiversity and climate change are acknowledged as crucial topics in course curricula, with the majority rating them as very important. However, input application garners a more diverse range of responses, with a notable proportion

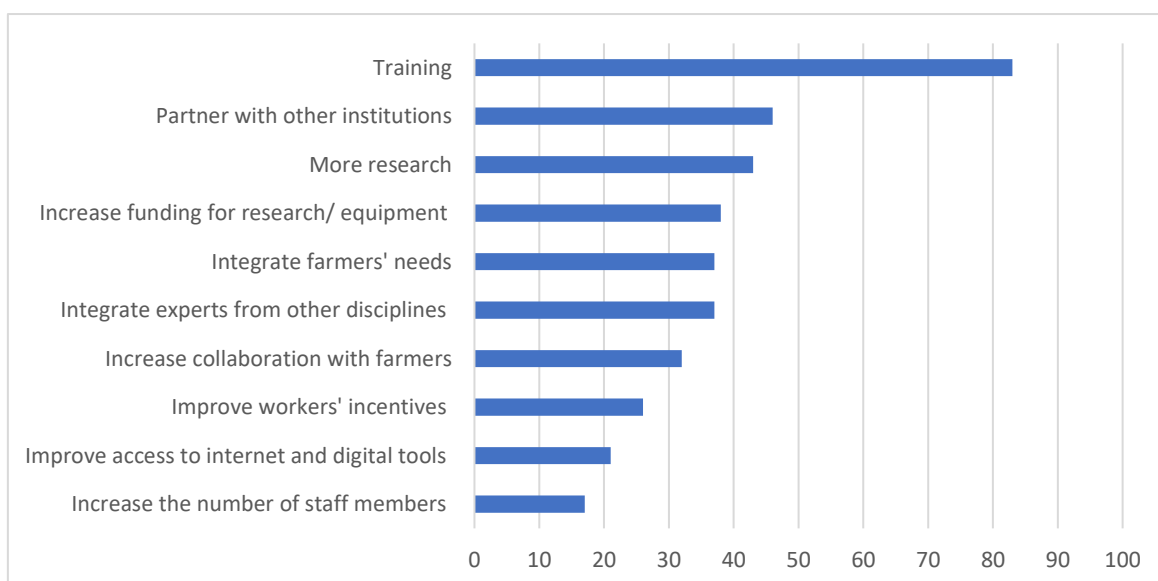
considering it important. Water management and soil fertility receive similarly high importance ratings, indicating a strong consensus on their integration into course curricula. Concerning animal welfare and the safe handling of inputs, a significant majority agrees that these are prominent topics in the course content.

Figure 4. Share of respondents recommending further emphasis on selected topics (%)



Source: Authors

Figure 5. Strategies for Enhancing Integration of Sustainability Topics in Course Curriculum (% of Respondents)



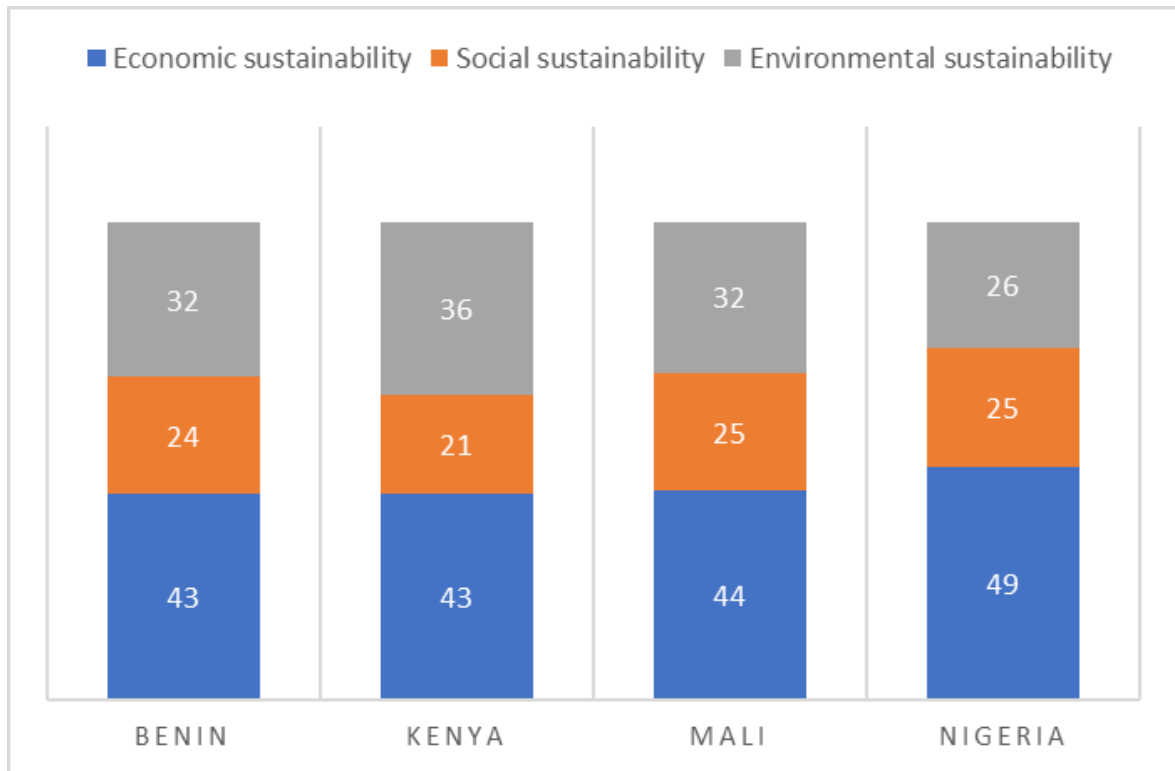
Source: Authors

While acknowledging the integration of topics covering all three dimensions of sustainability- environmental, economic, and social - the prevailing opinion among teachers is that the curriculum could benefit from additional content covering these topics. Figure 4 highlights a strong consensus among respondents from all four countries. Respondents in Kenya tend to demonstrate the highest needs for curriculum improvement on the levels of interest across most topics, while Benin generally shows slightly lower percentages but still significant interest. To achieve better integration of these subjects into the curriculum, respondents gave a range of suggestions as presented in Figure 5. Training emerges as the main recommendation, with an over 83% of respondents emphasizing its importance for successful integration of each sustainability-related topics in course curriculum. Additionally, respondents highlighted the significance of partnering with other institutions, as well as increasing collaboration with farmers and integrating experts from various disciplines. Other notable suggestions include addressing the needs of farmers and improving access to digital tools.

4.2.2. Students' perspectives on curriculum content

Figure 6 displays students' perceptions on the share of curriculum time allotted to various sustainability topics. On average, they perceived that over 40% of the learning time is devoted to subjects related to economic sustainability goals, encompassing areas such as productivity and commercialization, among others. The next most covered topics pertain to environmental issues, including the efficient use of fertilizers, biodiversity conservation, soil fertility management and climate-change related topics. Social topics take on slightly above 20% of the time allocated to ATVET content. This trend is similar across all four countries. To gain deeper insights into the content of ATVET curriculum, students were asked to express the degree to which they agreed with statements eliciting the coverage of specific economic, social and environmental topics.

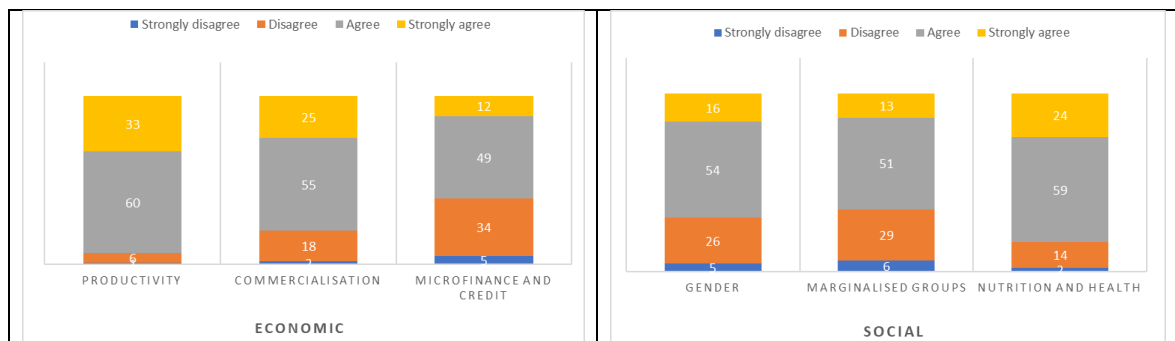
Figure 6. Students' perceptions on the share of curriculum time allotted to economic, social and environmental topics

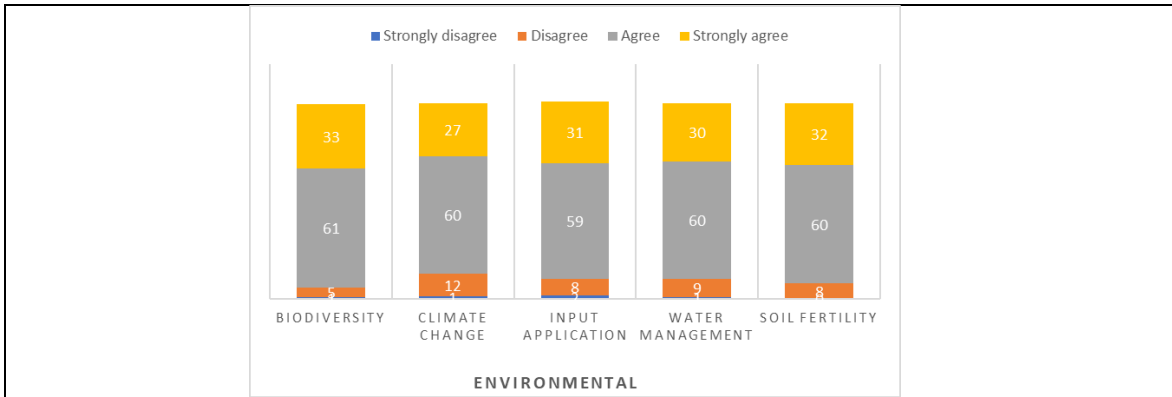


Source: Authors

Figure 7 illustrates students' responses on the coverage of specific topics in course curricula. The upper left graph presents students' viewpoints on the inclusion of economic topics in the ATVET curricula. The data indicates a widespread agreement among students regarding the need to incorporate these aspects, with the highest levels of agreement observed for productivity.

Figure 7. Students' perceptions on the coverage of specific topics by sustainability dimension (% of respondents)





Source: Authors

The second graph illustrates students' perceptions regarding the integration of social topics within the ATVET curriculum, specifically focusing on gender, marginalized groups, and nutrition and health. The majority of students agreed or strongly agreed with the integration of these topics, with high levels of agreement observed for gender and nutrition and health. Students also gave their perceptions on the coverage of environmental topics, such as biodiversity, climate change, input application, water management, and soil fertility, and their responses are illustrated in the lower graph. The data indicates that most students agree that their course curriculum covers environmental subjects, and this level of agreement was highest for topics on biodiversity and soil fertility.

4.3. Challenges and opportunities of agricultural education

4.3.1. Access to resources during agricultural education

Access to resources (or its lack thereof) can affect agricultural education and students' learning opportunities. Table 10 presents the major challenges students face in their journey to acquiring knowledge in agriculture.

Table 10. Challenges students face

		Benin	Kenya	Mali	Nigeria	All
Any challenges faced in course (Share yes) (%)		67	63	70	62	65
Challenges (%)	Insufficient access to internet	89	45	69	27	56
	Insufficient access to computers	67	38	63	33	50
	Insufficient access to relevant literature	42	14	55	22	34
	Not easy access to consult with teachers/lecturers	9	11	19	6	11
	Insufficient access to modern materials for practical lessons or laboratory	14	6	6	19	11
	Few practical lessons	7	18	8	9	10
	Financial constrains (fees, etc.)	5	13	7	1	6

Source: Authors

Overall, a significant percentage of students in all countries reported facing challenges in their courses, with the highest percentage in Benin (67%) and the lowest in Nigeria (62%). Limited access to internet (56%), computers (50%) and relevant literature (34%) appeared as major challenges experienced by students in the ATVET programs. Other challenges, such as "Not easy access to consult with teachers/lecturers," "Insufficient access to modern materials for practical lessons," "Few practical lessons," and "Financial constraints," are reported by smaller percentages of students across the countries, but they still represent notable concerns for some students.

Figure 8 presents students' perceptions on the adequacy of practical experience in ATVET across Benin, Kenya, Mali, and Nigeria. It also evaluates the extent to which courses facilitate interaction with farmers or visits to farms. A vast majority of students express satisfaction with the time allotted for practical works and opportunities for interaction with farmers (over 80% across all countries). Regarding the relevance of course materials, variations are observed across countries, but the majority of respondents either agree or strongly agree with the idea that the material provided in the course curriculum were adequate. On the adequacy of teaching facilities, including lecture rooms, variations were observed across countries. While the majority of students in Kenya, Mali and Nigeria have a positive impression of the facilities available for learning purposes, those in Benin, in a striking majority express dissatisfaction with the quality of the teaching facilities.

Figure 8. Perceptions of Practical Work, Farm Interaction, and Course Material Relevance across Countries



Source: Authors

On the importance of digital tools in learning and teaching, responses varied across students and teachers. Table 11 and Table 12 respectively report students' and teachers' usage of digital tools in their daily activities and academic endeavours. The majority of students reported that their courses included training on digital tools, with Kenya and Nigeria showing the highest percentages. Furthermore, a significant proportion of respondents expressed agreement or strong agreement with the course's capacity training in digital tools, with the exception of respondents in Benin who either disagreed or strongly disagreed. Despite this, the use of digital tools for academic tasks is reported to be substantial across all countries. Phones are the most commonly used devices, followed by computers, while tablets and GPS devices are less commonly utilized. Respondents primarily use these devices for research information on agricultural techniques, technical advice/training, and farm management practices.

Table 11. Digital tools usage among students (% of respondents)

		Benin	Kenya	Mali	Nigeria	All
Training on digital tools (yes %)		54	75	73	82	71
Perceptions on capacity on digital tools	Strongly disagree	33	3	5	9	12
	Disagree	32	21	25	29	27
	Agree	30	55	58	55	51
	Strongly agree	5	20	12	7	11
Use of digital tools in education (yes %)		64	94	79	89	81
Device used	Phone	100	100	98	99	99
	Computers	59	84	60	47	62
	Tablets	8	20	15	3	11
	GPS devices	2	6	13	2	6

Source: Authors

Table 12. Digital tool usage among teachers (% of respondents)

		Benin	Kenya	Mali	Nigeria	All
Daily digital tool use (yes %)		99.	96	99	99	99
Device used	Phone	100	100	98	98	99
	Computers	84	85	88	86.60	86
	Tablets	29	44	26	45	35
	GPS devices	26	13	24	22	22
	Other (Theodolite, drone)	6	0	4	1	3
Device purposes	Weather forecast	9	54	26	30	26
	Farm management practices	17	50	21	24	25
	Technical advice/training	28	52	37	42	38
	Business (e.g., marketing, financial literacy)	21	39	21	37	28
	Research information on agricultural techniques	60	85	66	63	66
	Teaching	77	83	90	76	81

Source: Authors

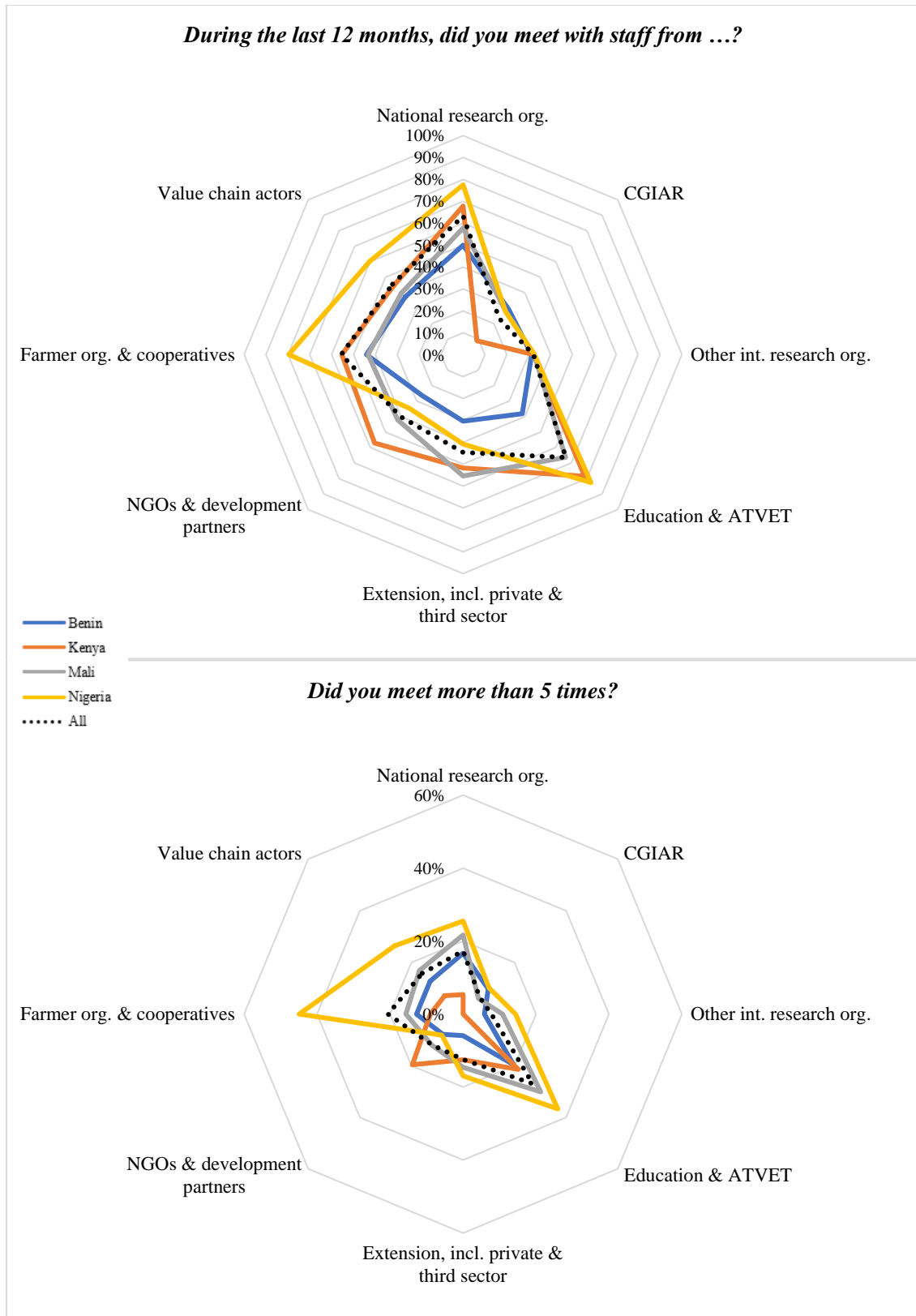
Similar results were found for teachers, whose vast majority reported integrating digital tools for teaching purposes. Teachers employed digital tools for a diverse range of purposes, including accessing weather forecasts, managing farms, accessing technical advice/training, and conducting research on agricultural techniques. Moreover, digital tools were utilized for teaching purposes, underscoring their role in facilitating educational activities and enhancing pedagogical practices. Messaging applications were predominantly used to communicate with colleagues from research and other colleagues

from the school/university. Additionally, teachers frequently exchanged messages with extension officers, farmers, traders, processors, and friends and family.

4.3.2. Partnerships and knowledge sharing opportunities for ATVET staff

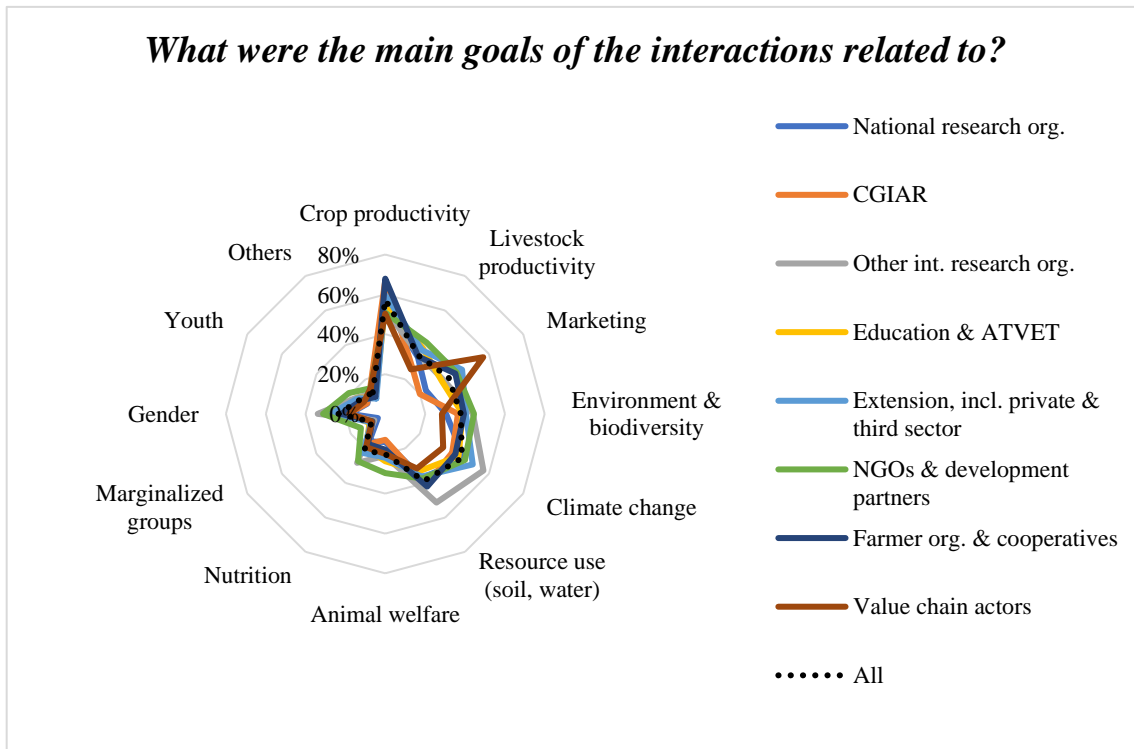
In the majority of ATVET settings, staff members reported collaborating with external institutions. As Figure 9 illustrates, ATVET staff interact with various types of institutions, including research, NGOs, extension services, as well as farmers' organisations or other ATVET. Most of the interactions take place with national research organisation, as well as with colleagues from other education and vocational schools. Respondents also cited farmers organisations as important especially, those in Nigeria. However, answers revealed limited interactions with CGIAR organisations, or value chain actors and extension services. Similarly, collaboration with NGOs and other related structures does not seem to occupy a significant place in teachers' activities. This is also evident in the frequency of interactions between ATVET staff and other organizations. Throughout the year, such interactions typically remain limited, with the number seldom exceeding 5. Indeed, less than half of the respondents admit to engaging with these organizations more than 5 times annually.

Figure 9. Collaboration with External Institutions and the Frequency of Interactions (% of respondents)



Source: Authors

Figure 10. Discussion Topics Among ATVET Staff and External Institutions



Source: Authors

Additionally, the topics discussed with their counterparts in the course of these interactions show some variations.

Figure 10 highlights the diverse array of topics that ATVET staff members discuss about with representatives from other institutions and organisations. The majority of the topics covered pertain to economic aspects. More than 60% of participants note that discussions with research organizations primarily focus on crop productivity-related themes. Some interactions also address topics like climate change and biodiversity. However, social issues such as gender, nutrition, or youth-related matters appear to receive less attention, with only a small number of respondents mentioning them.

5. Discussion

Gaining insight into the integration of sustainability topics into the curriculum of ATVET programs is crucial for fostering sustainable education for development, particularly in the realm of agriculture. This study used a survey involving over 300 teachers and 400 students to explore the perceptions of both groups regarding the coverage of various sustainability topics in ATVET curricula. Additionally, the study sought to identify challenges and opportunities for improving the ATVET as well as the integration of these topics into course curricula. Overall, the analysis indicates a broad coverage of all dimensions of sustainability

-environmental, social, economic- in course curricula. It also highlights the congruence in the perceptions of teachers and students regarding the extent of coverage of specific topics within each of these dimensions. Additionally, the findings revealed a number of challenges facing the smooth implementation of sustainability curriculum in ATVET, such as poor access to resources, including internet, computers, or reading materials, and weak linkages with stakeholders within the agricultural innovation system (as further discussed in 5.3.).

5.1. The state of curriculum in ATVET institutions

Training sustainability-literate professionals is essential for cultivating a workforce capable of tackling the diverse challenges confronting the agricultural sector (Durán Gabela et al., 2022; Nyamweru et al., 2023). Our findings indicate a clear intent to incorporate topics spanning all dimensions of sustainability—economic, social, and environmental. Teachers also expressed strong agreement on the statements eliciting the integration of selected sustainability concepts into their teaching. These results were different from Muma et al.'s (2010) result, who observed that teachers reported a moderate coverage of sustainable agriculture topics in their teaching. Our results indicate that agriculture teachers do include sustainable agriculture topics in their curricula, and this was confirmed from the students' responses. The majority of students and teachers either agreed or strongly agreed on the statements eliciting the inclusion of topics addressing all three dimensions of sustainability. These findings align with the research of Kidane & Worth (2014) in South Africa, who observed that students acknowledged adequate lesson coverage in their educational programs. However, the most substantial share of curriculum time is dedicated to economic subjects, like productivity or marketing. In contrast, social aspects such as gender, health, and nutrition, receive less attention, with about 25% of the total time allotted to these topics. In a similar vein, Muma et al. (2010) reported that the topics teachers taught in the United States were more related to ecological and social dimensions than the and social dimensions than the economic dimension.

The results also highlighted a discrepancy between students' s perceptions of the challenges farmers face, and their attitudes towards the ideal allocation of agricultural budget. The majority of students attributed a greater share of the hypothetical agricultural budget to economic aspects, while most of the challenges they identified could be classified in the environmental category. This divergence between agricultural students' perceptions of environmental challenges as more pressing for farmers while simultaneously expressing a preference to allocate more of the agricultural budget to economic issues may reflect a pragmatic approach influenced by the perception that farmers' problems, including social and environmental ones can be solved by addressing their economic challenges. It suggests that while there is a recognition of environmental challenges, there may be opportunities to further educate agricultural students on the interconnectedness of

environmental, economic, and social dimensions of sustainable agriculture. This could be done by implementing curriculum approaches which integrate innovations that reduce trade-offs between environmental and economic goals.

5.2. Teachers' qualifications in ATVET institutions

The effective integration of sustainability into ATVET curricula hinges on the provision of highly trained teachers with a skill set extending beyond a particular specialization. The findings indicate that the majority of ATVET instructors hold advanced degrees such as Masters or PhDs, highlighting the pool of expertise in agricultural education. Touchstone (2015) found similar results among ATVET teachers in Idaho, reporting that 45% of respondents held a master degree, though none had a PhD. Our results were also in line with Onu et al., (2019) whose sample consisted of more than 75% of ATVET educators with either a master's degree or a PhD. Conversely, our findings deviate from the results of Bashir, et al., (2019) who found that no more than 5% of ATVET educators in Nigeria had a master degree.

The findings also highlighted the diversity in the qualifications within ATVET institutions. The majority of ATVET teachers have a background in crop and horticulture or livestock, and a relatively lower share have expertise in the social and environmental sciences and technology. In contrast, only 6% had a background in environmental sciences, 4% in business and management, and 0% in health and nutrition. The high prevalence of lecturers trained in crop and horticulture or livestock (as well as technology and engineering) may reflect a traditional emphasis within agricultural education on agronomic and technical aspects rather than broader interdisciplinary perspectives. These results highlight the need to diversify the expertise among lecturers in agricultural education. Faculties should aim at recruiting more staff from different backgrounds to curtail to gap in the existing pool of expertise. This dominance may influence the content and focus of sustainability education within agricultural programs (Fekih Zguir et al., 2021), and challenge the opportunity for teacher to keep an interdisciplinary perspective to instruction (Roshania et al., 2023). In a study sustainability-related competencies among studying Greek agronomists, for example, Charatsari & Lioutas (2019) found that they are less likely to be skilled in marketing topics, reducing their willingness to seek collaborations with colleagues of this discipline. Damoah et al. (2024) also found that content taught in class was closely linked to the teachers' personal experience.

Also, curriculum delivery could be enhanced by investing in in-service training for ATVET staff and teachers, to facilitate their understanding of sustainability topics. Our findings reveal that approximately half of the teachers received training within the previous five years. The majority of respondents recognised that subjects spanning all sustainability

dimensions were addressed in the trainings they attended. Nevertheless, the majority identified training as the top one strategy needed to improve the integration of sustainability in course curriculum. These findings are in line with Clemons et al.'s (2018) who reported educators needs across a range of subjects spanning the socio-economic and environmental dimensions. Other studies have underscored the professional development needs of ATVET instructors in this regard. Hemmelgarn et al. (2019), for instance, reported that the integration of agroforestry topics in agricultural sciences programs could be improved by promoting teacher learning and professional development. This highlights the need for investing in teachers skills development (Carter et al., 2014; Walsh & Irving, 2020) for better infusion of sustainability topics in course curricula.

5.3. Structural conditions for sustainability in ATVET

5.3.1. Access to technology and learning materials for curriculum delivery and learning in ATVET

Innovative curriculum practices combining the use of digital tools and information technology can spark a positive transformation of the education system (Costan et al., 2021; Haleem et al., 2022). The rapid growth of digital technologies offers tremendous opportunities for enhancing students' learning experience and transmitting sustainability skills in agricultural training and education (Baptista et al., 2021). Our findings suggest that both students and teachers are well-acquainted with digital technologies and recognise their importance in both their daily activities and research endeavours. Similar results were found by Kaki et al. (2022) who identified that students demonstrated competence in utilizing online search tools, engaging in online collaborative activities, managing requests, and employing the Microsoft Office. This finding could indicate that students in our study have enough capacity on the use of digital tools. However, students' perceptions on the capacity on digital tools showed some mixed results, with a notable proportion of respondents across all categories either disagreeing or strongly disagreeing with the course's capacity building in digital tools. This is further reinforced by the type of devices students employ in their daily lives and for academic purposes. Our findings reveal that phones and, to a lesser extent, computers, are the predominant devices utilized by both students and teachers in their daily and academic activities. This suggest that while there may be some efforts in mainstreaming digital tools in course curricula, there may still be room for improvement in enhancing the integration and effectiveness of digital tools within ATVET programs. Additionally, the limited access to internet and learning materials are reinforcing the constraints to students' learning, threatening their capacity to benefit from new developments in agriculture.

Interestingly, practical experience held an important place in the learning experience of ATVET students. More than 80% of participants acknowledged the opportunity to interact

with farmers during their agricultural program and gained valuable insights from such interactions. These findings are corroborated by numerous studies, such as those conducted by Nyamweru et al. (2023) and Yusuf et al. (2021). This indicates that ATVET give as much importance to the theoretical foundations of sustainable agriculture as to the practical aspects needed for experiential learning. Hence, students have greater chances at developing skills and core competences in sustainable agriculture practices (Migliorini & Lieblein, 2016), while bridging abstract conceptualization and concrete experience (Parr & Trexler, 2011). Additionally, this practical experience may increase students' self-motivation for farm activities and increase the likelihood of them engaging in agriculture (Parr & Trexler, 2011). ATVET policies should strive to strengthen such collaboration with farming communities, and foster experiential learning opportunities that integrate theoretical knowledge with practical skills acquisition, ensuring students are well-equipped for sustainable agricultural practices throughout their careers.

5.3.2. Linkages, networks and sustainability in ATVET

Collaboration and coordination among various stakeholders, including educators, researchers, and industry experts, are central to integrating sustainability into agricultural education and course curricula (Agrawal & Jaggi, 2024; World Bank, 2012). Our study presents rather mixed results regarding the relationships between ATVET staff and other organizations. While they maintain fairly strong relationships with research institutions and farmers' organizations, their connections with international organizations or NGOs are limited. Additionally, these interactions are occasional and appear to focus more on productivity-related topics than on social aspects, including gender or marginalised groups. Roshania et al. (2023) reported similar weak linkages in a study where teachers highlighted the breach between academia and the 'real world'. The risk associated with such limited collaboration is teachers' lack of awareness of developments in different sectors, limiting their capacity to integrate innovative knowledge or methods into their courses. For example, Culhane et al. (2016) found that faculty members considered the sharing of disciplinary knowledge and course content among colleagues as crucial for tackling complex social issues within the context of sustainable agriculture education. The weak linkages between ATVET staff and other stakeholders may also contribute to a mismatch between the skills taught in ATVET programs and the needs of the industry, potentially exacerbating workforce shortages and skills gaps (Kaki et al., 2022). Coordination and collaboration with industry for example has the potential to increase students' employability and entrepreneurial skills (Soam et al., 2023). Given that the vast majority of the student respondents in our study aspires to careers in private entrepreneurship, fostering these collaborations is essential for the sustainable development of agriculture. Addressing this issue requires policy

interventions aimed at fostering greater collaboration, incentivizing partnerships, and aligning educational curricula with industry demands.

The weak linkages between the ATVET and other stakeholders or institutions may stem from the poor performance of the agricultural innovation systems in the surveyed countries. Barriers to collaboration, including institutional silos and limited communication channels, hinder knowledge exchange and technology transfer, slowing the pace of innovation, including in education. To enhance these capacities, universities may reform their curricula to include innovation systems approaches (Ortega-Dela Cruz, 2020; Van Staden, 2020; World Bank, 2012). This will likely necessitate collaboration among various institutional stakeholders, including the ministries of agriculture and education, to create a conducive environment for implementing policies promoting sustainable agriculture in course curricula (World Bank, 2012) .

6. Conclusion

Equipping the next generation with the necessary resources and skill sets to address global challenges towards achieving the Sustainable Development Goals has been high on the agenda of international organisations and governments across the world. Agriculture, in particular, plays a pivotal role in driving positive transformation, with the ATVET sector serving as a crucial component of agricultural innovation systems capable of catalysing these transitions. The purpose of this exploratory study was to describe the presence of sustainability topics within the agricultural curriculum of ATVET institutions in sub-Saharan Africa, and to identify the conditions for sustainability in ATVET curricula. The study has underscored a potential transformation occurring in the ATVET systems of the countries included in this study. There are obvious efforts underway to integrate a wide array of topics across all three dimensions of sustainability. Respondents in all countries have given positive responses to questions elucidating the inclusion of specific sustainability content in the course curricula. While some variations, the results indicate that all countries may have similar approaches to the integration of sustainability in their curricula. Nevertheless, students' and teachers' perspectives suggest that countries or ATVET programs still give prominent emphasis to economic topics, and may overlook important aspects within the social and environmental dimensions of sustainability. Addressing this imbalance is paramount, especially concerning social issues like nutrition, health, and gender equality in agriculture. Realizing meaningful integration necessitates curriculum reform and active participation from all stakeholders, including government bodies, to strengthen partnerships between agriculture and education ministries and ensure cohesive coordination. Only through collective efforts can these changes be implemented effectively, fostering a

curriculum that adequately prepares individuals to navigate the complexities of sustainable development and contribute to a more equitable and resilient future.

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