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The role of African universities in handling climate change

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Abstract

Background African countries are among the most vulnerable and affected by climate change. Comprehending climate change poses a major hurdle for the African population, politicians, and the African Union alike, presenting a substantial challenge for all involved. It is generally accepted that universities and other higher education institutions must play a leading role as drivers of change. Therefore, it is very important that African universities educate students about both mitigation and adaptation measures, develop the necessary initiatives to foster research in climate change-related topics and promote cooperation and alliances with key stakeholders.

Results This research reports on a study aimed at identifying the extent to which higher education institutions in Africa are engaging in efforts to deal with the challenges posed by climate change. The objectives were accomplished through a mixed method approach, incorporating a review of literature, an international survey, and the inclusion of selected case studies from African universities that have developed successful initiatives. The research has brought to light significant disparities, such as varying perceptions regarding the potential outcomes of climate change and its associated extreme events in African countries. In addition, the study highlighted areas where there is a notable consensus on specific issues. It also offers a comprehensive view of the different strategies that universities are implementing to contribute to climate change mitigation and adaptation in several areas. Although there is a growing interest in the need to contribute to the joint task of mitigating the effects of climate change and adapting to its consequences, HEIs need to increase their efforts to enhance the work of their professors and researchers. To this end, the involvement of public authorities and other private sector actors is essential.

Conclusions This article outlines some actions that need to be undertaken so that universities may play a more active role in global efforts to handle the problems associated with a changing climate. There is a notable focus from academic actors on addressing climate change challenges in Africa. In addition, there is a proactive emphasis on utilizing science and research to comprehend climate change issues and offer widely applicable tools for adaptation and mitigation to safeguard both people and the environment. Consequently, it is crucial and time-sensitive for African universities to enhance their expertise in the field of climate change, fostering the capacity to conduct innovative research that addresses the various challenges linked to the evolving climate. This study offers several useful lessons for African universities to replicate experiences that have generated results in different countries and contexts.

Keywords Climate change, Sustainability, Higher education, Universities, Africa

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Background

Africa is at a tipping point of climate change. The climate of Africa is reportedly warmer than it was 100 years ago, and a warming environment can place stress on water resources, whether the future rainfall pattern significantly changes or not [34]. Substantial inter-annual and multi-decade rainfall variations were observed with near continent-wide droughts [17]. Therefore, an increase in mean annual temperatures across the continent will exceed 2 °C and could rise by as much as 6 °C before the end of the twenty-first century. Though Africa has registered the lowest per capita emissions of any region of the world since 1960, the continent is considered one of the regions most vulnerable to climate change [43]. An increase in droughts, floods, and other natural disasters will make Africa's people, economy, and ecosystems even more vulnerable to the effects of climate change than the rest of the world [6]. This climatic characterisation of Africa makes it one of the most exposed continents due to its high vulnerability, and low adaptive capacity (Leal [23]). Therefore, it is unsurprising that climate change is identified as the continent's leading human and environmental crisis of the twenty-first century.

In addition, climate change can initiate international and intranational conflicts over shared natural resources and aggravate existing conflicts over natural resources. Thus, there is scientific and political consensus that climate change severely threatens African countries through the lives and livelihoods of their populations. However, the implication of taking action on climate change is a significant hurdle for African governments, as the action constitutes a substantial financial and political burden on leaders of the continent and donors as well [7].

Some obligations of African countries that are parties to the United Nations Framework Convention on Climate Change (UNFCCC) are carved around communication, information, and learning—under which such countries are to prepare national communications about emissions, vulnerabilities, financial resources, and public awareness of climate change [44]. Science and research are proactive approaches to understanding climate change issues and providing general adaptation and mitigation tools to people and the environment. In this light, it is essential and urgent for African countries to develop their human capacity in the climate change field to conduct cross-cutting edge research to find solutions to the challenges associated with the changing climate.

UNESCO reported a need to integrate sustainable development themes within teaching and learning, such as climate change [41]. Therefore, efforts are needed from universities around the world to develop advanced curricula, interdisciplinary collaboration, programmes, and capacity building to support deeper learning on climate

change and its related issues [11]. UNESCO and UNFCCC asserted that the Paris Agreement calls for the creation of new academic programmes across a diverse range of disciplines to ensure that future professionals have a better understanding of both the challenges posed by climate change and of the tools to be used for adaptation and mitigation processes (Leal [25]). Any attempt to adequately address the human capacity gap should focus on efforts at addressing climate change education and the role of African Universities. The role of universities in climate change education (CCE) is critical if the scientific, social, environmental, and political challenges confronting Africa is to be addressed through research [31]. However, the extent of African universities' contribution to addressing climate change issues appears to not be well-investigated in the literature. African universities can help produce knowledge on climate change, adaptation, and mitigation in support of policy formulation, implementation, evaluation, and monitoring of climate change projects. Therefore, they are very important in moving much of the African continent towards a sustained fight to reduce climate change and its impacts on the continent's development. It will set the base for a clear research agenda for the Africa Union regarding research policy and resource support. This study identifies the extent to which African universities are engaging in efforts to deal with climate change and its consequences, and it outlines some actions that need to be undertaken to effectively handle the problems related to climate change.

The effective achievement of the SDGs relies on capitalising on mutually reinforcing connections among the SDGs and fostering productive involvement among a wide range of stakeholders [4]. Nevertheless, today mankind is facing an urgent challenge regarding the feasible implementation of the 2030 Agenda [14]. Since time immemorial, universities and other higher education institutions (HEI) have been the cradle of formal knowledge generation [24]. Universities are knowledge conduits through which various concepts of climate change can be acquired at undergraduate and postgraduate levels [22]. It is generally recognised that universities must take the lead role as drivers of change [37]. Higher Education Institutions (HEIs) have the capacity to aid in the achievement of SDGs through what is commonly referred to as their 'first mission' of educating on sustainable development, their 'second mission' of conducting research related to sustainable development, and their 'third' mission of actively participating in the development of innovative strategies within communities to promote sustainability [29]. In addition to this, universities can also implement institutional and operational policies aimed at enhancing sustainable practices [20, 21].

Nevertheless, HEIs face several barriers to implement sustainable practices (Veiga [49]).

While the SDGs do not specifically target higher education, universities bear the responsibility to design curricula that impart knowledge of contemporary social and environmental issues [15]. This is usually achieved through constantly reviewing the curriculum [35, 36], as well as through the establishment of research centres [24]. Simultaneously, there is a growing call for universities to enhance their engagement with societal challenges, particularly from students who represent the future change-makers [4, 29]. Given this backdrop, universities are intensifying their endeavours to incorporate subjects related to sustainability into their curricula [2, 8]. However, the extent to which these matters are integrated varies according to the educational level and field of knowledge, and there is still potential for enhancement in numerous courses and programmes [3, 52]. In this regard, universities can be critical in promoting community behaviour change through pro-environmental education [12], community awareness and community engagements. The mainstreaming of climate change education across all levels of the education system can go a long way in tackling climate change.

Community awareness engagements are important as communication pathways to decode scientific research into understandable messages that are actionable. In this regard, the achievement of the SDGs necessitates collaboration among all sectors and stakeholders, involving the integration of their resources, knowledge, and expertise [27]. Building collaborations between universities and communities can play a vital role in advancing sustainability initiatives as a whole and contribute to the realisation of some of the SDGs [24]. Furthermore, universities continue to play a key role in conducting ground-breaking research regarding climate change mitigation and adaptation mechanisms. Examples of such include future climatic projections that can be used to craft climate change policy development for countries.

Engaging in partnership with local, national, and global organisations emerges as a crucial strategy for advancing progress toward the achievement of the SDGs within the realm of higher education. This approach holds the potential to strategically align universities with societal objectives, improve communication with local communities, and harmonise with agendas at all government levels [48]. Furthermore, it can amplify the influence of universities within local communities, influence national policies, and make substantial contributions to driving social change [51]. Universities can also play the role of synthesising and communicating climate scientific findings that are usually technical in nature into messaging that can be comprehended by the public. A well-informed society

can directly influence environmental policies that enable sustainable adaptive community practices.

Through active involvement in the fight against climate change, HEIs can offer research-driven and educational solutions for identifying the most pressing climate-related challenges and effective approaches for addressing them. HEIs can function as central hubs for the development, testing, and dissemination of information concerning climate mitigation and adaptation strategies. In addition, HEIs frequently engage in research endeavours and are well-positioned to generate novel knowledge for testing small-scale alternatives and improving operational practices. In this regard, for example, they can take the lead in crafting practices that reduce the amount of emissions through the adoption of green energy, improving mobility between and within campuses [53], cooperating with other stakeholders to provide evidence-based solutions [30], increasing biodiversity [40], or improving waste management [26], among others. Besides, by performing the role of knowledge generation on climate change, universities can contribute through the human resource development as well as capacity development of future climate change practitioners [16].

Methods

This research used a mixed method approach, combining a literature review, an international survey, and a selection of relevant case studies from African universities. Initially, we conducted a cross-sectional descriptive analysis of scientific literature pertaining to the intersection of “climate change” and “higher education” within African countries. This analysis was based on data obtained from the Scopus database, an online repository comprising approximately 23,400 available scientific journals that encompass a wide spectrum of research fields [13]. Scopus is a commonly utilised resource in bibliometric studies due to its extensive indexing of journals, surpassing the coverage of indexed journals provided by the Web of Science [10]. For our study, we retrieved documents that featured the terms “climate change” and “university*” or “higher education” in the title, abstract, or keywords. This retrieval encompassed the study period spanning from 2015 (the year in which the United Nations adopted the 2030 Agenda for Sustainable Development) to 2023.

Second, we used an international survey developed by the research team. The purpose of this questionnaire was to gather the participants’ perceptions related to climate change in Africa, assess the status of climate change teaching and learning in African universities, explore the issue of how to improve climate change and action, and investigate the role that African universities must play regarding climate change action [44]. To achieve these objectives, the questionnaire items were formulated

based on a thorough review of the existing literature pertaining to the role of universities in promoting sustainability through their activities in teaching, research, and organisational practices. To ensure the appropriateness and effectiveness of the survey items, a panel of experts in the fields of sustainability and higher education was consulted to provide guidance and validate the questionnaire prior to its use for data collection. Following the validation exercise, the research team adjusted the survey, including modifying the number of sections and items within each section as well as refining certain elements to better align with the research objectives. Subsequently, after incorporating the recommendations made by the experts and to ensure the reliability and consistency of the data, a pilot study (pre-test) was conducted involving five respondents. The outcome of this pilot test indicated that the survey instrument was suitable, requiring only minor refinements. Both phases of this process provided confirmation of the reliability and validity of the data collection instrument. The final version of the survey included 22 questions, structured in four sections, namely: “**Background**” section: identification (4 items), “**Methods**” section: status of climate change teaching and learning (2 items), “**Results and discussion**” section: ways for improving climate change and action (9 items), and “**Conclusions**” section: role that African universities (7 items).

A Google form was then created, incorporating the finalised survey questions. To reach a diverse African audience, a purposive sampling method—complemented by strategies like chain referrals and snowballing—was employed to distribute the online questionnaire link. This dissemination was facilitated through the collaborative efforts of the research team, as well as the networks associated with the European School of Sustainability Science and Research (ESSSR) and the Inter-University Sustainable Development Research Programme (IUS-DRP). Data collection took place over the period spanning from August 2022 to February 2023. Adhering to established research ethical protocols, participants were duly informed of the voluntary nature of their participation, the strict confidentiality of their responses, and the guaranteed security of their personal data.

In addition, this research included a set of relevant case studies to show some examples of successful initiatives implemented by African universities. For the collection of examples, a table was designed, which entailed a specific set of information, namely the country, the name of the university, the action or initiative, and its purpose. Also, to ensure the tracing of the information, the table contained weblinks. This also allowed a cross-check of the information and enabled readers to obtain further details. For the identification of the case studies, the

research team identified successful examples reflecting the following issues: innovative training programs with a focus on sustainability and climate change; creation of research centers on these issues; institutional strategies or initiatives aimed at improving university performance; institutional strategies aimed at generating multi-stakeholder partnerships; and research or professional training programs. The case studies were chosen aiming to show best practices in different African countries. The purpose was to identify one relevant example for 50% of the countries of origin of the participants in the survey, ensuring a representative geographic distribution of these countries.

Results and discussion

The first section of the survey addressed social, demographic, and academic characteristics of the respondents. The questionnaire allowed us to gather a representative sample from African universities, since 102 participants from 30 countries answered the survey. Table 1 shows the respondents’ social, demographic, and academic characteristics.

Regarding the gender of participants, 74% of them were male, and 26% were female. As regards age, the most common age group was formed by researchers between 36 and 50 years (53%). Regarding the level at which participants are currently teaching at the university, 60% teach in undergraduate programmes, 62% in graduate programmes, and 33% in doctoral

Table 1 Respondents’ social, demographic, and academic characteristics

Feature	Count
Gender	
Male	74%
Female	26%
Age	
18–25	4%
26–35	21%
36–50	53%
51–65	21%
+ 66 years	1%
Teaching levels of respondents	
Undergraduate programmes	60%
Graduate programmes	62%
Doctoral programmes	33%
Affiliation with academic programmes	
Natural sciences, mathematics, and statistics	25%
Agriculture, silviculture, fishing, veterinary	12%
Social sciences, journalism, and information	11%
Business, administration, and law	9%
Engineering, manufacturing, and construction	8%

programmes. As shown in the table, the affiliation of respondents to academic departments is diverse. Figure 1 shows the geographical distribution of participants and the number of responses gathered for each country.

“Methods” section focused on the participants’ perceptions related to climate change in Africa. It included a question regarding the respondent’s opinion about the potential consequences of climate change and extreme events in the continent. As shown in Fig. 2, there is a strong consensus regarding the perception of the outcomes that climate change and its related extreme events could generate in African countries. The issues on which there is the greatest consensus are land degradation, for which 82% of the participants declared a high level of agreement; food insecurity (81%); economic losses (69%), reduction of production and productivity (67%); and extinction of species and biodiversity loss (67%). Nevertheless, if we consider both the “highly agree” and “agree”

levels, there is a strong consensus around all problems and risks included in the questionnaire.

It also included a question regarding the respondents’ level of awareness or information about several theoretical concepts, international initiatives to raise awareness regarding the effects of climate change, calls for action, or key reports. In this regard, the answers are diverse. The results show that most of the respondents are aware or well-informed regarding the differences between the concepts of change adaptation, mitigation, and vulnerability. In addition, the participants declared that they are well-informed about the international debate about climate change. Similar levels of awareness or information were declared by respondents regarding the climate targets included in SDG 13 and the discussion and outcomes of the Conferences of the Parties (COPs) (organised within the UN Framework Convention on Climate), where 81% and 79% of respondents, respectively, declared that they strongly agree or agree. Nevertheless, the respondents

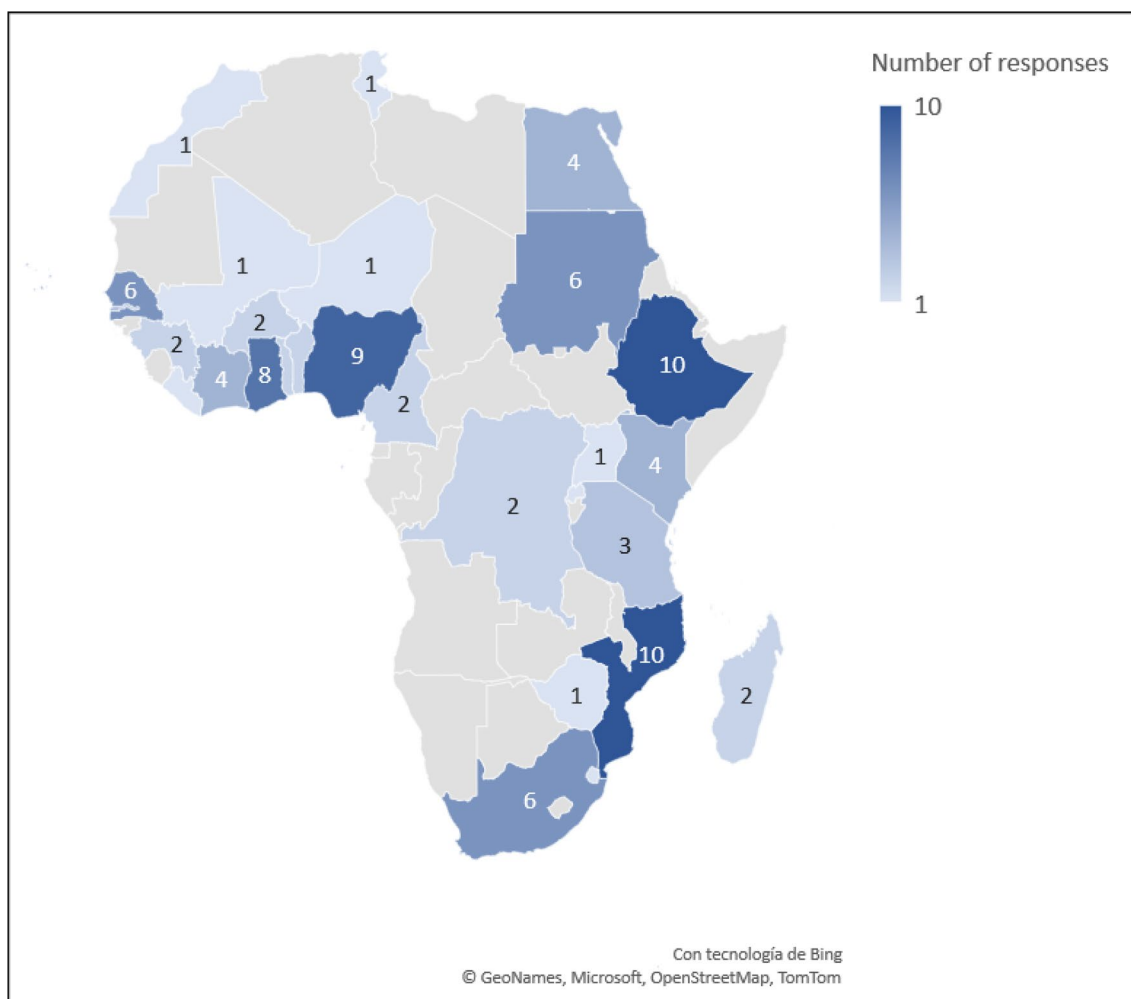


Fig. 1 Geographical distribution of participants. Source: Authors own elaboration

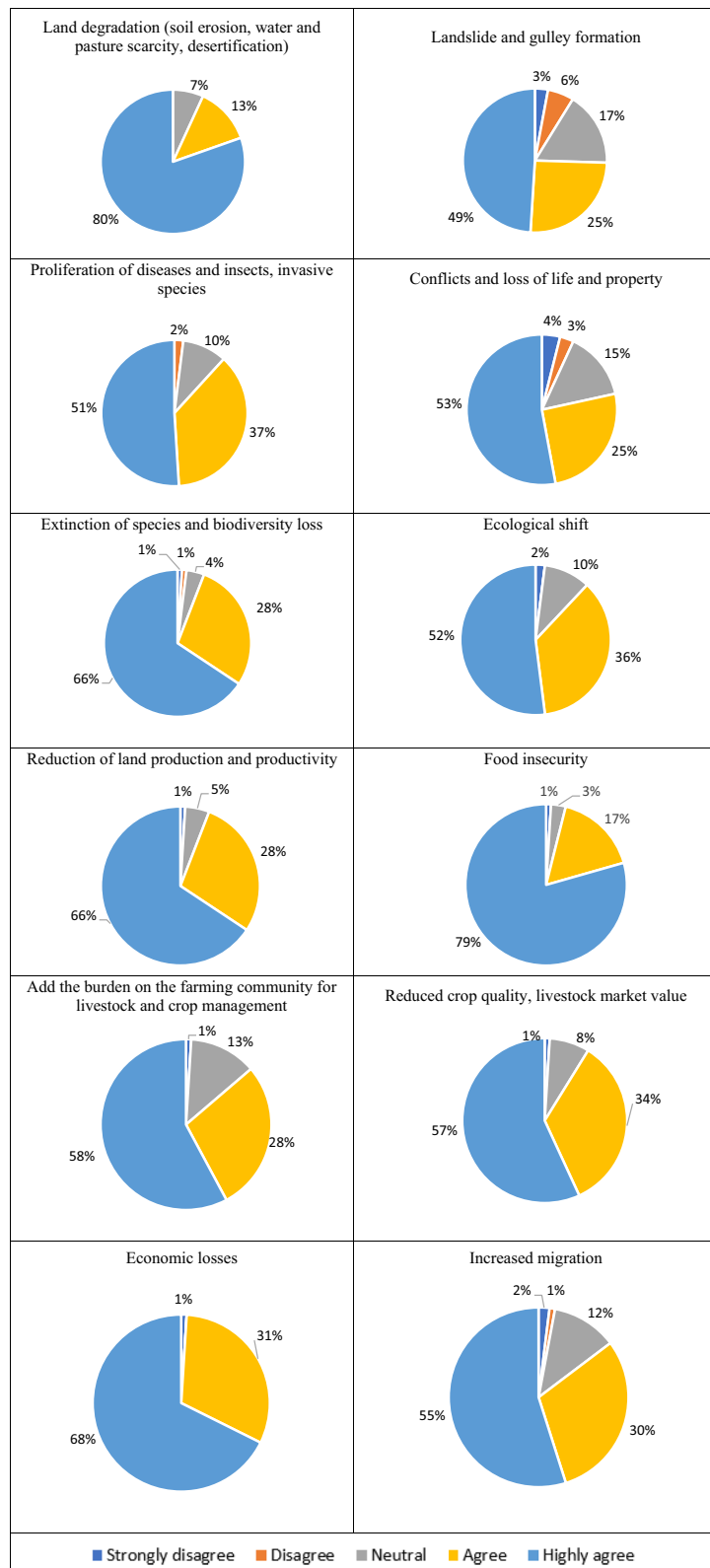


Fig. 2 Potential consequences of climate change and extreme events in Africa. Source: Authors own elaboration

recognized different levels of awareness and information regarding the movement “Fridays for the Future” and the latest assessment report (2023) (AR6), issued by the Intergovernmental Panel on Climate Change (IPCC [19]) (Fig. 3).

“Results and discussion” section focused on climate change teaching and learning in African universities. When asked about the importance of climate change teaching, 73% of the participants considered it very important and 17% important. However, 72% of respondents believed that the current climate change curricula at universities are not adequate to equip students with basic climate change skills and knowledge regarding adaptation and mitigation. When asked about the reasons for this, 47% of respondents believe that it is because of the lack of technology or pedagogical resources; 40% because of the lack of interest from university management; 28% think that it is because the topic is not a priority for the government; 15% declared that the reason for this is the lack of interest from students; and 10% identified other reasons. In addition to this, when asked about their university/institute’s contribution to support the education of students in this particular field, 59% of participants believed that it is low; 32% declared that it is high; and only 9% of respondents consider that it is very high.

As regards to how climate change is being taught at universities, 32% believe that the cases are being taught only in natural and applied sciences; 28% contend that it is taught across the university’s faculties; and 23% declared that it is being taught only in natural sciences. Regarding the level of emphasis on matters related to climate change in courses/programmes, 30% of the participants believe that the topic is not well-covered as they would like it to be; 27% consider that it is covered with enough information; 19% declared that it is poorly covered; and 17% think that it is very well-covered with

plenty of information. In this regard, when asked about the instructional techniques that are usually employed to teach climate change-related topics, the answers are diverse. The most popular method is the combination of traditional lecture and independent learning, as identified by 43% of respondents. This is followed by seminars (41%), lectures (39%), lectures supported by audio or video (38%), and project-based learning (33%). Zooming into details regarding which aspects of climate change are more frequently covered, the most cited is climate change impacts on national sustainable development and communities’ well-being (60%), followed by climate change adaptation (47%), mitigation (32%), health impacts (22%), and all equally (21%).

The survey also included two questions regarding the sources of information and the challenges to fostering communication on climate change. First, regarding the origin of teaching materials and content, the most reported sources are journal articles and academic chapters (77%); followed by international symposiums or events (54%), technical, research, and training platforms (53%); the university (42%); social media (33%); NGOs (28%); TV (24%); newspapers (22%); and radio (12%). Second, regarding potential problems that may hinder communication on climate change, 51% of respondents declared that the information is too scientific. This is followed by other challenges, such as the fact that 31% of participants believe that the information is too abstract or that impacts are too long-term; that information is perceived as too vague/unclear (29%); or that information has no connection with reality or is not context-specific (25%). Nevertheless, 16% of participants believe that there are no problems at all.

“Conclusion” section addressed the issue of how to improve climate change and action. There is a clear commitment towards the willingness to participate in more

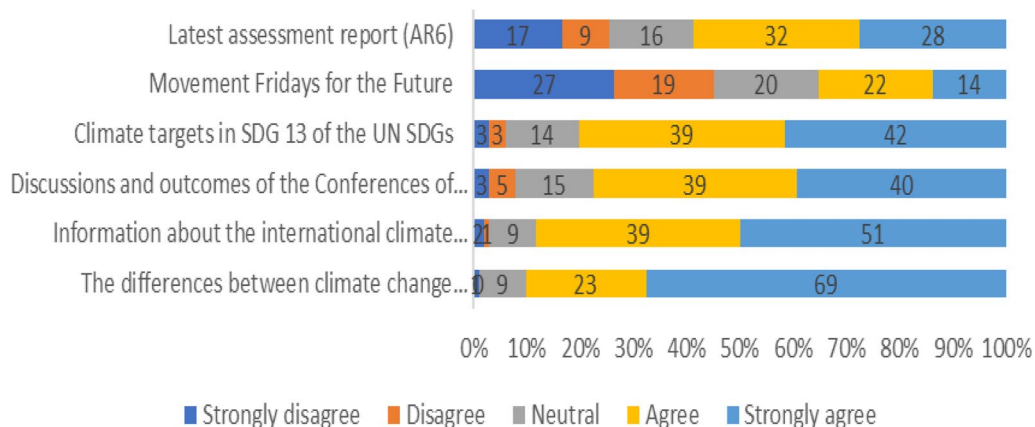


Fig. 3 Level of awareness or information regarding theoretical concepts and international initiatives. Source: Authors own elaboration

activities related to climate change at their institutions or communities, as recognised by 99% of participants. Zooming into details about what kind of activities, research on climate change is the most popular issue, as identified by 90% of participants. This is followed by training/capacity-building workshops (83%); gathering more content about it in their courses/teaching programmes (58%); volunteering or participating in community activities (57%); and helping or assisting student movements or protests for climate change awareness (46%). Regarding the participants' opinions about where more information about climate change education in university should come from, 71% of respondents believe that it should come from student projects; followed by the institutional strategic plan (69%); mandatory courses (68%); publications (66%); student clubs or associations (36%); career centres (28%); optional courses (27%); and placements in companies (26%). In line with this, regarding how to improve climate change streamlining in university activities, 83% of respondents believe that climate change concepts must be integrated into various modules/courses; 80% believe that these must be reflected in research, projects, and exhibitions; 49% think that these concepts must be handled through debates; and 43% consider that these issues should be introduced as a stand-alone programme. The survey also asked participants which topics they felt need further information. A large share of them (81%) recognised that they need more information regarding technologies that could help to mitigate climate change. In addition to this, 68% of participants declared that they need more information regarding approaches to climate change adaptation; followed by approaches to climate change mitigation (65%); climate change causes and impacts (52%); and SDG 13 (52%).

The survey also included four questions regarding the role that African universities must play regarding climate change action. 61% of the participants believe that their institution is committed to reducing its effects on the climate by implementing programmes/projects or re-equipping the facilities, while 39% of respondents consider that their institutions are not committed to these tasks. Nevertheless, several initiatives are being undertaken, such as the use of renewable energy sources (47%); the use of renewable materials only (28%); the installation of equipment for recovering potable water (18%); or the adoption of the 5R (Refuse, Reduce, Reuse, Repurpose, Recycle) (15%). When asked about what other roles African universities can play regarding climate change, a large share of the participants recognised that they should: assist in the development of climate change adaptation and mitigation policies (84%); conduct community awareness

activities on climate change (83%); conduct research on climate change (80%); develop climate change curricula for both high schools and university/polytechnic teachers; and develop social media content and spread media messages on climate change (58%).

Finally, participants were asked about how universities can best sustain their engagement in climate change initiatives and had to choose only three options among a set of alternatives. Results show that the respondents believe that universities must engage in partnerships with state and non-state agencies (87%); initiate entrepreneurial projects that are environmentally sustainable (78%); engage staff members in pooling technical and financial resources for climate change mitigation/adaptation (72%); work with industry (under the framework of Corporate Social Responsibility) (66%); and seek support from volunteers (24%).

As mentioned before, we aimed to complement the results of this survey by analysing a set of relevant case studies in detail. Table 2 shows a list of examples from 15 countries, which are explained below.

Algeria

The Pan African University Institute of Water and Energy Sciences (including Climate Change) (PAUWES) from the University of Tlemcen (Algeria) offers 3 MSc programmes in Water, Energy, and Climate Change. Each of these MSc is divided into two specialisation tracks: one focused on policy and another one with a technical approach (engineering track for the MSc in Water and Energy, and a technical track in the case of the MSc in Climate Change). These programmes are structured around the intersection between climate change—both mitigation and adaptation—and development. They are 2-year programmes that include a range of climate change topics, along 3 semesters, starting with an overview of the intersection between climate change and development. Then, students will choose between a policy track or a technical/engineering track for the following 2 semesters. The technical/engineering track of the programme provides advanced training in the technical and scientific dimensions of climate change. It allows students to acquire essential knowledge and skills in specific climate-related sectors and fields: interpretation of climate data and science, application of ICTS, as well as supporting skillsets for communication, knowledge management and visualisation of complex datasets, scenarios, and models. The policy track of the programmes provides advanced training in the policy and planning dimensions of water management, energy, and climate change, along with an understanding of the value of ethical and responsible governance [32].

Table 2 Case studies of successful initiatives in African higher education institutions

Country	Universities and Centres	Initiative	Purpose	Reference
Algeria	University of Tlemcen	Pan African University Institute of Water and Energy Sciences (PAUWES)	To equip professionals with a policy track or a technical/engineering track in the fields of Water management, Energy, and Climate Change	https://www.pauwes.dz
Botswana	University of Botswana	5 Research Institutes and Centres	To promote research and innovation in five key areas: ecosystem services; indigenous knowledge and innovation; clean energy; transport; and the San culture	https://www.ub.bw/research
Cape Verde	Public University of Cape Verde; University of Aveiro (Portugal); Polytechnic Institute of Tomar (Portugal); Federal University of Alagoas (Brazil); National Center for Monitoring and Alerts of Natural Disasters (CEMADEN) (Portugal); Polytechnic Institute of Bragança (Portugal)	Master's in Climate, Natural Resources, and Risks	To prepare professionals in climate and climate change research; monitoring and forecasting extreme precipitation events (floods) in the different regions of Africa in a context of global climate patterns or through forecasting techniques (radar and satellite)	https://unicv.edu.cv/pt/ensino/cursos/mestrados/2627-clima-recursos-naturais-e-riscos
Ethiopia	(white for anonymity)	Institute for Development Policy and Research	To commence and carry out research efforts focused on development and policy, aimed at producing comprehensive insights into the social, economic, political, and environmental development challenges faced by Ethiopia and the global community as a whole	http://www.aau.edu.et/idpr/
Egypt	American University of Cairo	American University of Cairo Climate Change Initiative	It involves research, student events, teaching, and learning, as well as outreach events. These areas are in line with climate change and sustainability priorities both at the national and regional levels	https://www.aucegypt.edu/climate-change
Gambia	(white for anonymity); West Africa Science Service Centre on Climate Change and Adapted Land use (WASCAL)	Research Master's Programme on Climate Change and Education	To provide climate change expertise to students from the ten West African countries in an engaging, multidisciplinary, and inter-cultural learning environment	https://wascal.org/
Kenya	University of Nairobi	Institute for Climate Change and Adaptation	To equip students and train professionals with knowledge and skills in the science and practical applications in climate change science	https://icca.uonbi.ac.ke/
Mozambique	Eduardo Mondlane University	Master's in risk management of Disasters and Adaptation to Climate Changes	To prepare qualified professionals to deal with disaster risk management and climate change, with a view to building community resilience	https://www.uem.mz/index.php/ensino/pos-graduacao/102-graduacao/mestrado/1152-mestrado-em-gestao-do-risco-de-desastres-grd-e-adaptacao-as-mudancas-climaticas

Table 2 (continued)

Country	Universities and Centres	Initiative	Purpose	Reference
Morocco	Mohammed VI Polytechnic University (UM6P)	Sustainable Development Plan of Actions and Sustainable Development Policy	Two institutional agendas for guiding actions undertaken by the UM6P's departments, research centres, and offices in teaching, research, and management activities	https://sd.um6p.ma/
Nigeria	Alex-Ekwueme Federal University Ndufu-Alike (AEFUNA)	Centre for Climate Change and Development	Contribute to innovative learning, research, and policy guidance in the areas of environmental sustainability, climate change and green development in Nigeria and Africa	https://cccd.funaiedu.ng/
Senegal	University Cheikh Anta Diop (UCAD)	Doctoral Research Programme in Climate Change Economics	To apply economic principles in the examination of climate change adaptation and mitigation strategies	https://wascal.org
South Africa	Stellenbosch University	School for Climate Studies	Transdisciplinary capacity to combine the climate-related knowledge systems of SU's faculties, the public sector's climate policies and initiatives and the private sector's climate redress and innovation capacities	https://climate.sun.ac.za/
Togo	Université de Lomé	Doctoral Research Programme in Climate Change and Disaster Risks Management	To educate students about the challenges and dangers posed by climate change	https://wascal.org
Tunisia	National Agronomic Institute of Tunisia (INAT)	Several engineering, master and doctoral programmes with a focus in sustainability	To centralise sustainability in the economy, production processes, and consumption behaviours through the implementation of technical innovations and novel managerial approaches	http://www.inat.tn/fr
Uganda	Makerere University	Makerere University Centre for Climate Change Research and Innovation	To train postgraduate students at both MSc and PhD level in climate change-related fields	https://www.mucri.mak.ac.ug/

Botswana

The University of Botswana has created five research institutes and centres to promote research and innovation in five key areas: ecosystem services, indigenous knowledge, clean energy, transport, and the San culture. The Okavango Research Institute (ORI) focuses on research projects that address climate change, ecosystem dynamics, ecosystem services, sustainable tourism, and water resources management. The Centre for Scientific Research, Indigenous Knowledge, and Innovation (CesriKi) is an interdisciplinary research centre where several scientific projects are implemented to foster research, documentation, education, and awareness. These projects address four axes: health, food systems, agriculture, and environmental management. All these projects highlight the need to include participatory action research methodologies to enhance links with local communities. The Clean Energy Research Centre (CERC) aims to help local actors to develop clean energy projects. The Botswana Transport Technology Unit aims to support the government and other stakeholders' initiatives aiming to foster the development of the transportation sector. Finally, the San Research Centre seeks to inform stakeholders about the San culture socio-economic and political issues [46].

Cape Verde

The University of Cape Verde is delivering a Master's degree in Climate, Natural Resources and Risks. The programme has an international orientation by integrating the International Center for Climate Research and Applications for the CPLP and Africa (CIICLAA), of which the following universities are part: University of Cape Verde (Cape Verde), University of Aveiro (Portugal), Polytechnic Institute of Tomar (Portugal), Federal University of Alagoas (Brazil), National Center for Monitoring and Alerts of Natural Disasters (CEMADEN) and Polytechnic Institute of Bragança (Portugal). The goal of this MSc is to prepare professionals to integrate multidisciplinary teams that work in the areas of climate and climate change research, characterising risks and proposing technically and financially feasible solutions; risk and disaster management and requalification; and monitoring and forecasting extreme events in the different regions of Africa in a context of global climate patterns or through forecasting techniques [33].

Ethiopia

(White for anonymity) incorporated climate change, climate change adaptation and development courses in MA/MSc and Ph. D programme curricula in the health, natural and social colleges. AAU established the Climate

Science Center (CSC) in 2010 to facilitate climate change adaptation and mitigation research, training, and capacity building, as well as to organise knowledge and technology sharing platforms and disseminate research outputs among stakeholders. Accordingly, a memorandum of understanding was signed with local universities, government ministries, research institutions, universities, and NGOs. In addition to this, in 2021 the Institute for Development Policy and Research (IDPR) of the (white for anonymity) [1] launched a joint doctoral research programme in development studies in collaboration with the Institute of Social Studies of Erasmus University (The Netherlands). This programme aims to educate graduate students and help them become high level experts in development studies with sound theoretical, analytical and interpretation abilities. In this regard, the doctoral programme seeks to: equip highly competent experts in policy and development issues with essential skills in research; educate experienced professionals who might work in higher education institutions; and train specialists in leadership and development studies for becoming leaders in development and climate change-related policy initiatives. In parallel to the doctoral programme, the IDPR is involved in several research projects, both at national and international levels that address issues related to health, resource-stressed populations, rural transformation, food security, land use, soil conservation, agricultural productivity, water management, and drought management, among other topics directly affected by the outcomes generated by climate change (white for anonymity).

Egypt

The American University of Cairo (AUC) Climate Change Initiative is structured around the academic and research proficiency at the AUC's departments and research centres and builds upon the university's intense international collaboration with other universities and research centres to address climate change-related issues from five focus areas: water scarcity, energy transition, green finance, urban development, and public health. The three axes for the implementation of the initiative are the activities undertaken by: the Center for Applied Research on the Environment and Sustainability, which inspires and supports sustainable development actions; the Office of Sustainability, which is in charge of managing AUC's environmental and climate change-related challenges; and several academic programmes: including two undergraduate programmes in (1) Physics with a specialisation in Solar Energy and (2) Architectural engineering; four master's programmes in (1) Environmental Systems Design, (2) Environmental Engineering, (3) Sustainable Development, and ((4) Global Public Health; a

PhD program in Engineering; and several diplomas and professional programmes [5].

Gambia

The (white for anonymity), in collaboration with the West Africa Science Service Centre on Climate Change and Adapted Land use (WASCAL), is leading the development of actions to address the negative impacts of climate change, with the aim to improve the lives and livelihoods of people in West Africa and beyond. In 2012, UTG introduced the 2-year Master's Research Programme in Climate Change and Education in The Gambia to provide climate change expertise to students from the ten West African WASCAL countries in an engaging, multidisciplinary, and intercultural learning environment. The programme aims to help address the challenges of climate change and variability, thereby improving the resilience of human and ecological systems. It consists of 24 modules on different areas of climate change, research practice, and pedagogy. Ten to twenty students are enrolled in each cohort, with an emphasis on developing skills in communication, education, and outreach, which are essential for policy advocacy, raising public awareness of climate change, and implementing adaptation programmes. Eighteen of its citizens have already graduated in different areas of climate change, nine of them at the Master's level and the others at the PhD level. Upon completion of the programme, graduates are well-prepared to work as education experts and communications officers for national and international agencies, the media, and civil society and donor organisations. While some of them will continue their academic careers in education or communication studies, most graduate students are currently working in their various countries in West Africa. In addition, the (white for anonymity) is involved in recruiting Gambians to specialise in other climate change programmes throughout West Africa [50].

Kenya

The University of Nairobi (UONBI) (Kenya) is committed to enhancing local, national, and international efforts to strengthen research, education and capacity-building regarding climate-change mitigation and adaptation initiatives. One of the best examples of UONBI's commitment to this collective mission was reflected by the foundation in 2011 of the Institute for Climate Change and Adaptation (ICCA). The Institute was created to develop the human expertise required to address the distinctive climate change and adaptation requirements of vulnerable communities. This mission is pursued through educational endeavours, research with practical applications, the innovation of new technologies, and active involvement of communities. Furthermore, the Institute

plays a crucial role in offering expert guidance for the formulation and execution of climate change policies. Their efforts to enhance education in this area are achieved by providing formal training in climate change science and adaptation at the postgraduate level, both in Master's and Doctorate programmes [47]. In this regard, the Master of Science programme in Climate Change and Adaptation is designed to train skilled personnel in Climate Change Science for sustainable development. The programme is uniquely broad in its coverage and reflects the range of knowledge and skills required to address the challenges of climate change and sustainable development [47].

Mozambique

Mozambique's geographical, hydrological, and climatic characteristics render it highly susceptible to the impacts of climate-related events, such as tropical cyclones, floods, droughts, extreme temperatures, and precipitation variations, among others. Presently, the consequences of these phenomena are becoming increasingly apparent, exerting substantial adverse effects on both the social fabric and the national economy. Furthermore, the frequency and severity of these events in Mozambique are on the rise due to climate change, heightening the country's vulnerability. To address these emerging challenges, the Master's programs in Management of Disasters and Adaptation to Climate Changes of the University Eduardo Mondlane was established with the primary aim of producing proficient experts who can make significant contributions to various aspects of disaster risk management and climate change adaptation. To achieve this objective, the programme is structured to provide a comprehensive understanding of disaster risk and climate change, with a particular emphasis on their implications for sustainable development. Consequently, the specific objectives of the master's programme encompass the provision of both theoretical and practical foundations in the realms of disaster risk and climate change science, underscoring the inherent interconnectedness between disaster risk reduction and climate change adaptation, and nurturing the problem-solving skills through the utilisation of techniques and tools that enable the anticipation of potential disaster events and associated processes [45].

Morocco

The Mohammed VI Polytechnic University (UM6P) has been very active in recent years in their efforts to address environmental and climate change-related issues. Initiatives implemented by the institutions and its departments and research centres in teaching, research, and management activities are inspired by two core agendas: the Sustainable Development Institutional Policy (SDIP)

[42], and the Sustainable Development Plan of Actions (DPA) [42]. The SDIP aims to guarantee the coherence and effectiveness of initiatives seeking to address sustainable development challenges, to assure the adherence of the UM6P community to sustainable values, to enhance sustainable results in education and research, and to contribute to generating solutions for sustainable development-related issues in Africa [43]. The DPA is structured into six categories: characteristics, academics, engagement, infrastructure and operations, planning and administration, and innovation and leadership. It is consistent with the Sustainability Tracking, Assessment and Rating System (STARS) standards, a framework designed to help higher education institutions in their efforts regarding sustainable practices [38].

Nigeria

The Centre for Climate Change and Development (CCD) is a think tank from the Alex-Ekwueme Federal University Ndufu-Alike (AEFUNAI). The CCD seeks to foster innovative learning, research, and policy guidance in the fields of environmental sustainability, climate change and green development. In this regard, the CCD aims to bring Nigerian scholars, public officers, NGOs, and private companies together in collaborations to deal with the nation's crucial environmental and developmental challenges. In this context, the CCD provides research analysis, consultancy services, trainings, advocacy, stakeholder guidance, and policy engagement to actors involved in sustainable development and climate change initiatives in Nigeria and Africa. It also facilitates space for strengthening relations between international and African scholars, with the purpose of better comprehending the multifaceted challenges and opportunities that the green economy poses for reducing poverty and inequality in Africa. The CCD's activities are focused on four core topics: Climate Policy and Justice, The Green Economy and Sustainable Development, Climate Adaptation and Resilience, and Climate Information Services [9].

Senegal

The University Cheikh Anta Diop (UCAD) in Dakar holds the distinction of being the oldest university among francophone African countries, and it boasts a diverse student body from 44 different nationalities. In addition to its six faculties, the UCAD houses a range of specialised schools in journalism, environmental studies, engineering, and public health. Within its academic landscape, the Doctoral Research Programme in Climate Change Economics (CCEcon) was established in 2023 under the leadership of UCAD, as part of a broader initiative known as the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL).

CCEcon is dedicated to the application of economic principles in the examination of climate change adaptation and mitigation strategies. It endeavours to adapt an interdisciplinary and comprehensive approach to the analyses and policy formulation related to climate issues. The program also fosters collaborative ties with other universities participating in the WASCAL Graduate Studies Programme (GSP). Since its creation, 40 West African students have followed the programme, and 29 of them already hold a PhD [50].

South Africa

The School for Climate Studies of the Stellenbosch University (SU) (South Africa) is a world-class academic faculty conducting interdisciplinary and transdisciplinary climate-related research in and for Africa. The school is active through four core axes: research and development; learning and teaching; collaboration, capacity-building and consultancy; and commercialisation and social impact. The activities in these spheres are structured around five key areas: the natural environment; health and human security; systems and technologies for the future; human creativity and social innovation; and social justice and development. Based on this solid framework, the school develops Africa-relevant research programmes that respond to climate change impacts, adaptation, and mitigation responses, supporting human climate resilience. The approach is based on transdisciplinary thinking and research on climate and on platforms for data-intensive research and innovation. It also facilitates and develops climate change curricula, across multiple faculties at SU through undergraduate and postgraduate modules, and coordinates internal and external climate training through workshops, short courses, training events, and congresses [39].

Togo

The Doctoral Programme in Climate Change and Disaster Risk Management was established at the Université de Lomé, as part of the WASCAL. This programme aims to educate students about the challenges and dangers posed by climate change. It also aims to familiarise them with the development of early warning systems and strategies to enhance the resilience and adaptive capacity of socio-ecological systems affected by these changes. Students enrolled in this programme are exposed to interdisciplinary and transdisciplinary approaches for assessing threats and are encouraged to collaborate within multidisciplinary teams that work alongside affected communities to harness their inherent resilience to various hazards. The University of Lomé, which is responsible for running this Doctoral Research Programme, comprises six faculties, nine schools and institutes, two centres

for professional training, and four centres of excellence, including the Regional Centre of Excellence on Poultry Science, the Regional Centre of Excellence for Electricity Management, the Centre for Sustainable Towns, and the WASCAL Graduate Research Programme. 41 West African students have participated in the programme, which has produced 30 theses so far [50].

Tunisia

The National Agronomic Institute of Tunisia (INAT) of the University of Carthage aims to place sustainability at the core of the economy, production systems, and consumption habits by employing technical innovations and novel management approaches, with the overall purpose of making sustainable development a shared responsibility between different stakeholders. INAT puts great importance on the synergy between higher education and research. With a strong emphasis on sustainable development issues, INAT possesses a diverse array of internationally recognised expertise, boasting approximately 100 permanent research professors in various fields. These areas encompass biodiversity and environmental studies, the design and management of natural and cultivated ecosystems, marine ecosystems, water resources and environmental studies, as well as animal production. In this context, INAT seeks to achieve two vital missions. First, it aims to provide initial training, primarily for engineers, Masters, and PhD students, as well as offering ongoing education in collaboration with numerous partners. Second, it endeavours to engage in the creation and dissemination of knowledge through research and development activities conducted in collaboration with research institutions and prominent professional technical centres. To achieve these goals, INAT hosts a doctoral school, five laboratories, and a research unit focused on addressing priority issues [18].

Uganda

The Makerere University Centre for Climate Research and Innovations (MUCCRI) was established in 2013 with the primary objective of promoting awareness about climate change and cultivating a knowledge base for innovative solutions. This is achieved through research, educational programmes, policy advocacy, and outreach initiatives. MUCCRI plays a crucial role in keeping Makerere University and other Ugandan institutions informed about the evolving scientific understanding of climate change, its impacts on Uganda, and strategies for addressing associated challenges. Teams at MUCCRI are actively involved in research, training, and policy discussion across various domains, including climate science, adaptation, mitigation, governance, and finance. The centre has actively encouraged the participation of the entire

campus community in climate change awareness initiatives. Its overarching mission is to heighten awareness of climate change, foster a knowledge-driven approach through research and innovation, and actively engage in the formulation of climate policies and outreach efforts. The goal of MUCCRI is to facilitate and coordinate collaborative research and innovation efforts that transcend disciplinary boundaries and address the multifaceted challenges posed by climate change [28].

Conclusions

This research has identified some of the main issues and challenges facing African universities as they work to help mitigate the effects of climate change and adapt to its consequences. A mixed method approach, combining a literature review, an international survey, and a selection of relevant case studies from African universities, was used to achieve the study's objectives.

This research has identified some of the main issues and challenges facing African universities as they work to help mitigate the effects of climate change and adapt to its consequences. The study has exposed the substantial disparity, for example, in the perception of the outcomes that climate change and its related extreme events could generate in African countries. The study also revealed that the issues on which there is the most remarkable consensus are land degradation, for which 82% of the participants declared a high level of agreement; food insecurity (81%); economic losses (69%), reduction of production and productivity (67%); and extinction of species and biodiversity loss (67%).

Moreover, in general, researchers and professors in higher education institutions consider that they are well-informed and prepared to deal with the challenges of education and research related to climate change. Also, the participants declared they were well-informed about the international debate about climate change. Similar levels of awareness or information were expressed by respondents regarding the climate targets included in SDG 13 and the discussion and outcomes of the Conferences of the Parties (COPs) (organized within the UN Framework Convention on Climate).

However, there is also a general opinion on the need to adapt the content of training programs, to design and implement ambitious strategies at the institutional level, and they also consider that a greater involvement of public authorities is necessary. In this sense, it is clear that there is a desire to create multi-stakeholder alliances and promote existing ones, with the aim of increasing synergies in the fight against climate change and its consequences on society, the economy and the environment.

This paper has some limitations. The first is the fact that the literature review focused on the intersection of

“climate change” and “higher education” within African countries and did not take into account informal education. Second, the sample of experts surveyed was not large enough to allow certainty in the trends identified. In addition, despite having participants from 30 countries, the number of responses was uneven, so there are disparities in the level of representativeness of some countries. Against this background, this line of research can be improved in the future by obtaining a larger and more balanced sample across countries. Finally, the case studies involved a limited set of African universities, building a rough profile of the current situation. Despite these constraints, the paper provides a welcome addition to the literature since it sheds some light on some of the issues related to how African universities handle climate change. This may offer support to future efforts in this field.

In respect of future trends, it is very important that adequate policies are put into place, to assist African universities to better handle climate change as part of their research and teaching programmes. Also, further studies which investigate how universities may better interact and exchange experiences are also needed, with a view to identifying appropriate measures to support this process.

In conclusion, the study was timely and relevant, particularly in showing how climate change has and is still impacting Africa and the role of African universities, particularly in contributing to the knowledge, disseminating it, and the overall community awareness activities regarding climate change mitigation and adaptation.

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Author contributions

WLF: conceptualization, methodology, formal analysis, investigation, data curation, writing—original draft, writing—review and editing, visualization, supervision, project administration. JS: methodology, formal analysis, investigation, data curation, writing—original draft, writing—review and editing, visualization, supervision. FK: formal analysis, investigation, writing—original draft. DYA: formal analysis, investigation, writing—original draft. NM: formal analysis, investigation, writing—original draft. CIVPAC: formal analysis, investigation, writing—original draft. BLS: formal analysis, investigation, writing—original draft. RA: formal analysis, investigation, writing—original draft. JM: formal analysis, investigation, writing—original draft. LZ: formal analysis, investigation, writing—original draft. DB: formal analysis, investigation, writing—original draft.

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