



Reawakening sustainable research practices in Nigerian higher education: A mediation analysis of innovative capacity

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Submitted: 6 March 2026 Revised: 23 May 2026 Accepted: 5 July 2026 Published online: 26 September 2026

Abstract

Sustainable research practices are increasingly important in higher education due to the growing global emphasis on environmental, social, and economic sustainability. This study examined the influence of environmental awareness, knowledge of ethical guidelines, and institutional culture on sustainable research practices, with innovative capacity serving as a mediating variable. A cross-sectional survey design was adopted, and data were collected from 1,411 valid respondents across selected higher education institutions. The data were analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM), while the measurement model was evaluated through reliability and validity assessments. The findings revealed that environmental awareness and knowledge of ethical guidelines significantly enhance sustainable research practices, whereas institutional culture provides an enabling environment that supports these relationships. Furthermore, innovative capacity significantly mediates the relationships between environmental awareness, ethical knowledge, and sustainable research practices, demonstrating its central role in promoting sustainability-oriented research behaviours. The study highlights the importance of strengthening institutional policies, fostering innovation, and enhancing sustainability awareness to improve sustainable research practices within higher education institutions. The findings provide practical implications for policymakers, university administrators, and researchers seeking to integrate sustainability principles into research systems and contribute to the growing body of knowledge on sustainable research in higher education.

Keywords: Environmental consciousness; Ethical guidelines; Higher education; Innovative capacity; Institutional culture; PLS-SEM; Sustainable research practices

1. Introduction

As global challenges continue to rise, sustainable research practices have become a crucial focus in academic, policy, and industry sectors. The quest for sustainable solutions aims to balance societal progress with environmental care and economic stability. Research is essential in generating knowledge, but it often involves processes that can have substantial environmental, social, and economic impacts. These range from the high consumption of resources like energy and materials to ethical concerns regarding data privacy and inclusivity. Consequently, there is growing recognition of the need to integrate sustainable practices into research processes to reduce harmful effects and contribute positively to global sustainability objectives.

Sustainable research practices are practices in research that align research aims with the broader principles of sustainable development. This includes responsible resource management, fostering inclusivity and fairness, and ensuring that research outcomes provide societal value. For example, the United Nations' Sustainable Development Goals (SDGs) offer a comprehensive framework for researchers to address key global challenges such as poverty, environmental protection, and health improvement (United Nations, 2015). Aligning research with these goals allows researchers to support the global effort toward sustainable development. The urgency of adopting these practices is heightened by the growing environmental and social issues of the 21st century. Problems such as climate change, environmental degradation, and the unsustainable use of natural resources present serious obstacles to global prosperity and demand a rethinking of how knowledge is generated and applied (Waas et al., 2011). Research institutions, as hubs of knowledge creation and dissemination, play a key role in leading this transformation. By embedding sustainability into their research, teaching, and institutional operations, they not only reduce environmental impacts

but also ensure that research contributes meaningfully to solving societal challenges (Velazquez et al., 2006; Findler et al., 2019).

Despite these obvious advantages, the implementation of sustainable research practices faces multiple challenges. These include limited funding and research resources, institutional resistance to organizational change, inadequate sustainability awareness, publication pressures, and the absence of standardized frameworks for evaluating sustainable research practices (Lozano, 2011; Lozano et al., 2015; Bauer et al., 2020). Equally important are weak interdisciplinary collaborations, insufficient institutional incentives, and governance structures that do not adequately support sustainability initiatives (Findler et al., 2019; Leal Filho et al., 2019). Furthermore, although organizations such as UNESCO have consistently advocated the integration of sustainability into higher education and research, translating these principles into practical institutional actions remains a significant challenge (UNESCO, 2021). The diversity of research environments across disciplines, institutions, and geographical contexts further complicates the development of universally applicable sustainability frameworks. Consequently, many institutions continue to experience inconsistencies in implementing sustainable research practices, thereby limiting their contribution to global sustainable development.

The growing dependence on digital technologies has introduced both opportunities and challenges for sustainable research. Digital platforms have enhanced international collaboration, virtual meetings, data sharing, and knowledge dissemination, thereby reducing the environmental impacts associated with physical travel and improving research efficiency (Leal Filho et al., 2019). Nevertheless, digital transformation also presents sustainability concerns, including increased energy consumption by digital infrastructure, unequal access to digital technologies, and disparities in research capacity across developed and developing countries (World Bank, 2023). Within the Nigerian context, persistent underfunding of higher education continues to constrain researchers' ability to conduct high-quality and internationally competitive research. Limited access to modern laboratories, digital databases, advanced analytical software, and research funding significantly restricts research productivity and innovation (World Bank, 2023; UNESCO, 2021).

Similarly, inadequate mentoring opportunities remain a major challenge to research development within many Nigerian higher education institutions. Effective mentorship plays a critical role in developing research competence, strengthening methodological skills, and promoting scholarly productivity (Crisp & Cruz, 2009; Eby et al., 2013). However, where mentoring structures are weak, early-career researchers often struggle to acquire the practical research competencies required for high-quality scientific inquiry. Recent reviews further indicate that structured mentoring systems significantly enhance researchers' confidence, collaboration, and long-term academic development (Nuis et al., 2023). In addition, limited interdisciplinary and international collaboration continues to restrict innovation and sustainable research development. Contemporary research increasingly depends on collaborative and multidisciplinary approaches to address complex global challenges, yet many researchers in developing countries remain constrained by inadequate institutional support, limited funding opportunities, and insufficient digital infrastructure (Council on Undergraduate Research, 2023; World Bank, 2023). These challenges underscore the importance of examining how digital transformation, institutional support, environmental consciousness, and innovation capacity collectively influence sustainable research practices.

Various studies have explored sustainability in higher education and related sectors, offering valuable insights into sustainable research practices. For example, Lozano et al. (2015) examined sustainability implementation in higher education institutions worldwide and emphasized the need for comprehensive strategies that integrate sustainability into institutional governance, curricula, research, and campus operations. Similarly, Leal Filho et al. (2019) investigated universities' global contributions to the Sustainable Development Goals (SDGs), noting that although awareness of sustainability has increased considerably, translating sustainability commitments into concrete research and institutional practices remains a significant challenge.

Findler et al. (2019) further demonstrated that higher education institutions contribute to sustainable development through research, teaching, community engagement, and institutional operations, although these contributions vary considerably across institutions. Likewise, Bauer et al. (2020) observed that effective sustainability governance requires strong institutional leadership, coordinated policies, and organizational commitment to facilitate sustainable transformation within universities. At the institutional level, Wright (2010) found that leadership commitment and organizational vision are critical for embedding sustainability within university systems, while Lozano (2011) emphasized that sustainability reporting serves as an important mechanism for monitoring institutional commitment and improving sustainable performance. Furthermore, Sonetti et al. (2019) argued that universities play a strategic role in advancing sustainable development by integrating sustainability into research, innovation, and societal engagement. Similarly, Velazquez et al. (2006) highlighted that institutional policies, governance structures, and stakeholder participation are essential for developing sustainable universities. More recently, Schaap et al. (2025) demonstrated that innovative capacity strengthens institutional transformation by enabling universities to respond more effectively to sustainability challenges through continuous learning and innovation. While these studies provide valuable insights into sustainability within higher education, limited attention has been given to understanding how environmental consciousness, knowledge of ethical guidelines, institutional culture, and innovative capacity interact to influence sustainable research practices. Consequently, the mechanisms through which innovative capacity strengthens these relationships remain insufficiently understood, particularly within the context of developing countries such as Nigeria.

This study contributes to the growing body of knowledge on sustainable research practices by integrating environmental consciousness, knowledge of ethical guidelines, institutional culture, and innovative capacity within a single conceptual framework. While previous studies have largely examined these constructs independently (Lozano et al., 2015; Findler et al., 2019; Bauer et al., 2020), relatively little empirical evidence exists on how they collectively influence sustainable research practices in higher education, particularly in developing economies. By introducing innovative capacity as a mediating variable, this study extends the application of the Triple Bottom Line framework and demonstrates how innovation can strengthen the translation of environmental awareness, ethical knowledge, and institutional support into sustainable research outcomes. Furthermore, the study responds to calls by UNESCO (2021) and the World Bank (2023) for stronger institutional research capacity, sustainable innovation, and responsible research systems within higher education. Given the infrastructural, financial, and governance challenges confronting many African universities, the findings provide practical evidence to guide policymakers, university administrators, and researchers in developing institutional strategies that promote environmentally responsible, socially responsive, and economically sustainable research practices.

2. Literature Review

2.1. Studies on Sustainable Research Practices

Sustainable research practices encompass the methodologies, approaches, and strategies employed throughout the research process to minimize adverse environmental, social, and economic impacts while maximizing long-term benefits for researchers, institutions, and society. These practices emphasize responsible resource utilization, adherence to ethical principles, transparency, and inclusivity in research design and implementation. By aligning research activities with the principles of sustainable development and the United Nations Sustainable Development Goals (SDGs), sustainable research promotes knowledge generation that addresses present societal needs without compromising the ability of future generations to meet their own needs (UNESCO, 2021; Lozano et al., 2015). The importance of sustainable research practices has increasingly been recognized within higher education because universities serve as centres for knowledge creation, innovation, and societal transformation. Consequently, integrating sustainability into research

activities strengthens institutional contributions to environmental stewardship, economic development, and social well-being (Findler et al., 2019; Leal Filho et al., 2019).

The adoption of sustainable research practices provides multiple benefits across environmental, social, and economic dimensions. Environmentally, sustainable research minimizes resource consumption, reduces waste generation, and encourages environmentally responsible research methodologies (Velazquez et al., 2006). Socially, it promotes ethical conduct, inclusiveness, stakeholder engagement, and research that addresses pressing societal challenges (Sonetti et al., 2019). Economically, sustainable research improves resource efficiency, reduces unnecessary research expenditure, and enhances the long-term viability and impact of research investments (Lozano, 2011). Furthermore, universities that embed sustainability principles into research governance and institutional policies are better positioned to produce research outcomes that influence policy development, strengthen community engagement, and contribute meaningfully to sustainable development (Wright, 2010; Bauer et al., 2020).

A comprehensive understanding of sustainable research practices requires the integration of environmental, economic, and social sustainability rather than emphasizing only one dimension. According to Elkington's (1997) Triple Bottom Line framework, sustainable development can only be achieved when environmental protection, economic prosperity, and social equity are pursued simultaneously. This perspective has been reinforced by Findler et al. (2019), who argued that universities contribute to sustainable development through interconnected functions involving research, teaching, institutional governance, and community engagement. Likewise, Waas et al. (2011) emphasized that sustainability should be viewed as a multidimensional concept that integrates ecological integrity, social responsibility, and economic viability. Consequently, research that prioritizes environmental sustainability while neglecting economic feasibility or social inclusion may have limited practical impact and fail to address complex societal problems effectively.

Recent studies have continued to strengthen understanding of sustainability within higher education institutions. Lozano et al. (2015) demonstrated that successful sustainability implementation requires institution-wide commitment involving research, teaching, campus operations, and governance. Similarly, Leal Filho et al. (2019) reported that although universities worldwide have increased their commitment to the Sustainable Development Goals, many institutions still struggle to translate sustainability policies into measurable research practices. Findler et al. (2019) further observed that while higher education institutions increasingly contribute to sustainable development, institutional performance differs considerably depending on governance structures, leadership commitment, and stakeholder engagement. Bauer et al. (2020) also found that sustainability governance is strengthened by effective institutional leadership, strategic coordination, and supportive organizational cultures. More recently, Schaap et al. (2025) concluded that innovative capacity is essential for enabling higher education institutions to respond effectively to sustainability challenges and continuously improve institutional performance.

Despite these important contributions, important knowledge gaps remain. Existing studies have primarily concentrated on institutional sustainability, governance, curriculum development, and sustainability reporting, with comparatively limited attention given to sustainable research practices at the individual researcher level. Furthermore, although previous studies have examined sustainability governance (Bauer et al., 2020), institutional commitment (Lozano et al., 2015), and innovation capacity (Schaap et al., 2025), few have investigated how environmental consciousness, knowledge of ethical guidelines, institutional culture, and innovative capacity interact to influence environmental, economic, and social sustainable research practices simultaneously. Empirical evidence addressing these relationships remains particularly limited within African and Nigerian higher education institutions. Addressing these gaps is important for developing evidence-based institutional policies and practical strategies capable of strengthening sustainable research practices while supporting the achievement of the Sustainable Development Goals. Consequently, the following hypotheses were formulated to guide the study.

2.2. Studies on Environmental Consciousness

Environmental consciousness refers to the awareness, attitudes, and behaviours that individuals develop toward protecting and preserving the environment. It reflects an understanding of the relationship between human activities and environmental sustainability, encouraging responsible actions that minimize environmental degradation and promote sustainable development. Beyond environmental knowledge, environmental consciousness fosters values and behavioural intentions that prioritize environmental protection as both an individual and collective responsibility. Such awareness contributes to responsible resource utilization, waste reduction, and environmentally sustainable decision-making, thereby supporting global sustainability initiatives such as the United Nations Sustainable Development Goals (UNESCO, 2021). According to Ajzen (1991), individuals are more likely to engage in environmentally responsible behaviour when they possess favourable attitudes, supportive social norms, and a strong sense of behavioural control. Similarly, Kollmuss and Agyeman (2002) argued that environmental consciousness extends beyond awareness to include the motivation and willingness to translate environmental concern into sustainable behaviour.

Environmental consciousness is closely associated with sustainable research practices because researchers who appreciate environmental challenges are more likely to design research that minimizes ecological impacts, utilizes resources efficiently, and adheres to ethical standards. Such researchers are also more inclined to adopt environmentally responsible methodologies and develop innovative solutions that contribute to sustainable development. Gericke et al. (2019) demonstrated that sustainability consciousness positively influences sustainability-oriented behaviours among stakeholders, while Leal Filho et al. (2019) emphasized that strengthening sustainability awareness within higher education institutions enhances the integration of sustainable development principles into research, teaching, and institutional operations. Similarly, Findler et al. (2019) argued that higher education institutions contribute significantly to sustainable development by promoting environmentally responsible research, knowledge creation, and community engagement. Consequently, environmental consciousness strengthens researchers' commitment to ensuring that research activities contribute positively to environmental conservation and long-term societal development.

Recent studies have continued to highlight the importance of environmental consciousness in promoting sustainability within higher education. Gericke et al. (2019) developed and validated the Sustainability Consciousness Questionnaire, demonstrating that sustainability awareness positively influences attitudes and behaviours that support sustainable development. Likewise, Leal Filho et al. (2019) found that although universities have increasingly embraced sustainability initiatives, translating environmental awareness into institutional practice remains a significant challenge. Bauer et al. (2020) further observed that sustainability governance is strengthened when environmental awareness is supported by institutional leadership, policies, and coordinated implementation strategies. In addition, Findler et al. (2019) reported that higher education institutions contribute more effectively to sustainable development when environmental consciousness is integrated into research, teaching, institutional management, and community engagement. Despite these important contributions, empirical evidence examining the direct relationship between environmental consciousness and sustainable research practices remains limited, particularly within African and Nigerian higher education institutions. Furthermore, little attention has been given to the mediating role of innovative capacity in strengthening the influence of environmental consciousness on sustainable research practices. Addressing these gaps provides the justification for the present study.

2.3. Studies on Knowledge of Ethical Guidelines

Knowledge of ethical guidelines refers to researchers' understanding of the principles, standards, and regulations that promote integrity, fairness, transparency, and accountability throughout the research process. It encompasses issues such as informed consent, confidentiality, responsible data management, objectivity, and the honest dissemination of research findings. Within the context of

sustainable research, ethical knowledge ensures that research activities contribute positively to society, protect the rights and welfare of participants, and minimize potential environmental and social harm. Ethical research practices also strengthen public confidence in scientific findings and promote responsible knowledge generation that supports sustainable development (UNESCO, 2021). Researchers who possess adequate knowledge of ethical guidelines are better equipped to balance scientific advancement with environmental protection, social responsibility, and economic accountability.

Knowledge of ethical guidelines is closely associated with sustainable research practices because researchers who understand and apply ethical principles are more likely to conduct research that is environmentally responsible, socially inclusive, and economically sustainable. Ethical compliance promotes transparency, responsible resource utilization, and accountability throughout the research process, thereby strengthening the credibility and long-term value of research outputs. Lozano et al. (2015) emphasized that institutional commitment to sustainability requires ethical governance and responsible research practices that integrate environmental, social, and economic considerations. Similarly, Findler et al. (2019) argued that sustainable development within higher education depends on responsible research, institutional governance, and stakeholder engagement, all of which are grounded in ethical principles. Bauer et al. (2020) further observed that effective sustainability governance requires institutional policies that encourage ethical decision-making, accountability, and responsible research conduct.

Recent studies continue to demonstrate the importance of ethical principles in promoting sustainability within higher education institutions. Leal Filho et al. (2019) reported that universities are increasingly integrating sustainability into research and teaching; however, the successful implementation of these initiatives depends largely on institutional commitment to ethical governance and responsible leadership. Likewise, Wright (2010) found that institutional leadership and shared organizational values are fundamental for embedding ethical and sustainable practices within university systems. Furthermore, UNESCO (2021) emphasized that responsible research and innovation require strong ethical frameworks capable of addressing emerging environmental, technological, and societal challenges. More recently, Schaap et al. (2025) highlighted that innovative capacity is most effective when supported by ethical leadership and institutional governance that encourage responsible innovation and sustainable decision-making.

Despite these important contributions, significant knowledge gaps remain. Existing studies have primarily examined ethical governance, institutional sustainability, and responsible research separately, with relatively limited attention given to the influence of researchers' knowledge of ethical guidelines on sustainable research practices. Furthermore, few empirical studies have investigated how ethical knowledge interacts with environmental consciousness, institutional culture, and innovative capacity to promote environmental, economic, and social sustainable research practices simultaneously. These gaps are particularly evident within African and Nigerian higher education institutions, where empirical evidence remains limited. Addressing these shortcomings provides the rationale for the present study.

2.4. Studies on Institutional Culture

Institutional culture refers to the shared values, beliefs, norms, practices, and behaviours that shape how individuals within an institution interact, make decisions, and perform their responsibilities. It encompasses both formal structures, such as institutional policies, governance systems, and operational procedures, as well as informal practices that influence collaboration, innovation, leadership, and research activities. Institutional culture plays a critical role in determining how organizations respond to emerging challenges, embrace innovation, and pursue sustainable development. Within higher education, a supportive institutional culture promotes ethical conduct, environmental responsibility, collaboration, and continuous improvement, thereby creating an environment that encourages sustainable research practices (Wright, 2010; Bauer et al., 2020). Such institutional environments foster knowledge sharing, interdisciplinary

collaboration, and long-term strategic planning that are consistent with sustainable development objectives (Lozano et al., 2015).

Institutional culture is strongly associated with sustainable research practices because universities with sustainability-oriented values are more likely to establish policies, governance structures, and organizational systems that encourage environmentally responsible, socially responsive, and economically sustainable research. Institutions that promote collaboration, innovation, and continuous learning provide researchers with the support necessary to address complex sustainability challenges. Findler et al. (2019) reported that higher education institutions contribute to sustainable development through the combined influence of institutional governance, research, teaching, and community engagement. Similarly, Bauer et al. (2020) found that sustainability governance is strengthened when institutional leadership, organizational commitment, and coordinated policies are aligned with sustainability objectives. Furthermore, Lozano (2011) observed that universities with strong sustainability cultures are more likely to institutionalize sustainability reporting and integrate sustainable practices into their research and operational activities.

Recent studies continue to emphasize the importance of institutional culture in advancing sustainability within higher education. Leal Filho et al. (2019) demonstrated that institutional commitment, leadership support, and organizational collaboration are essential for translating sustainability policies into meaningful research and educational outcomes. Likewise, Sonetti et al. (2019) argued that universities play a strategic role in achieving sustainable development when institutional culture supports innovation, stakeholder engagement, and responsible governance. More recently, Schaap et al. (2025) concluded that institutional culture provides the foundation upon which innovative capacity develops, enabling universities to respond more effectively to sustainability challenges through continuous organizational learning and innovation. These findings suggest that institutional culture extends beyond administrative structures to become a strategic driver of sustainable research and innovation.

Despite these important contributions, significant gaps remain in the literature. Most previous studies have examined institutional sustainability, governance, leadership, and organizational commitment independently, with limited attention given to how institutional culture interacts with environmental consciousness, knowledge of ethical guidelines, and innovative capacity to influence sustainable research practices. Furthermore, empirical evidence addressing these relationships remains scarce within African and Nigerian higher education institutions, where financial constraints, inconsistent leadership commitment, and limited institutional resources often impede sustainability initiatives. Addressing these gaps will contribute to a better understanding of the institutional conditions necessary for promoting environmentally responsible, socially responsive, and economically sustainable research practices.

2.5. Studies on Innovative Capacity

Innovative capacity refers to the ability of researchers and academic staff to generate new ideas, develop creative solutions, and implement novel approaches that improve research quality and institutional performance. It encompasses creativity, critical thinking, adaptability, problem-solving, and continuous learning, together with an organizational environment that encourages experimentation, collaboration, and knowledge sharing. Within higher education, innovative capacity enables researchers to respond effectively to emerging scientific challenges, develop interdisciplinary solutions, and produce research with greater societal relevance and sustainability. The development of innovative capacity depends not only on individual competencies but also on institutional support, leadership commitment, and opportunities for collaborative learning (Schaap et al., 2025).

Innovative capacity is fundamental to promoting sustainable research practices because it enables researchers to develop environmentally responsible methodologies, optimize the use of available resources, and generate innovative solutions to complex societal challenges. Researchers with strong innovative capacity are more likely to integrate sustainability principles into research

design, data collection, analysis, and dissemination, thereby contributing to environmental protection, economic efficiency, and social well-being. Bell (2010) emphasized that innovative and project-based approaches strengthen critical thinking, creativity, and problem-solving skills that are essential for addressing contemporary sustainability challenges. Similarly, Blumenfeld et al. (1991) argued that engaging researchers in authentic problem-solving activities enhances creativity, collaboration, and the practical application of knowledge to real-world issues. Within higher education, innovative capacity has therefore become an important driver of sustainable research and institutional transformation.

Recent empirical studies have continued to demonstrate the importance of innovative capacity within higher education. Bhattacharyya et al. (2018) found that research experiences enhance researchers' confidence, creativity, and professional development, thereby strengthening their capacity for innovation. Likewise, Appel et al. (2024) reported that participation in authentic research experiences improves students' ability to think critically, solve complex problems, and develop innovative research competencies. Similarly, Chamely-Wiik et al. (2023) observed that intensive engagement in research activities significantly enhances research competence, innovation, and long-term academic success. More recently, Schaap et al. (2025) concluded that innovative capacity is a critical organizational capability that enables higher education institutions to respond effectively to sustainability challenges through continuous learning, knowledge creation, and institutional adaptation.

Despite these important contributions, important gaps remain in the literature. Most previous studies have examined innovative capacity as an outcome of research engagement, institutional learning, or educational innovation, with comparatively limited attention given to its role as a mediating mechanism linking environmental consciousness, knowledge of ethical guidelines, and institutional culture to sustainable research practices. Furthermore, empirical evidence examining this mediating role remains scarce within African and Nigerian higher education institutions. Understanding how innovative capacity translates environmental awareness, ethical knowledge, and supportive institutional cultures into environmentally, economically, and socially sustainable research practices therefore represents an important contribution to both sustainability and higher education research. Consequently, this study proposes that innovative capacity serves as a critical mediating variable in explaining sustainable research practices.

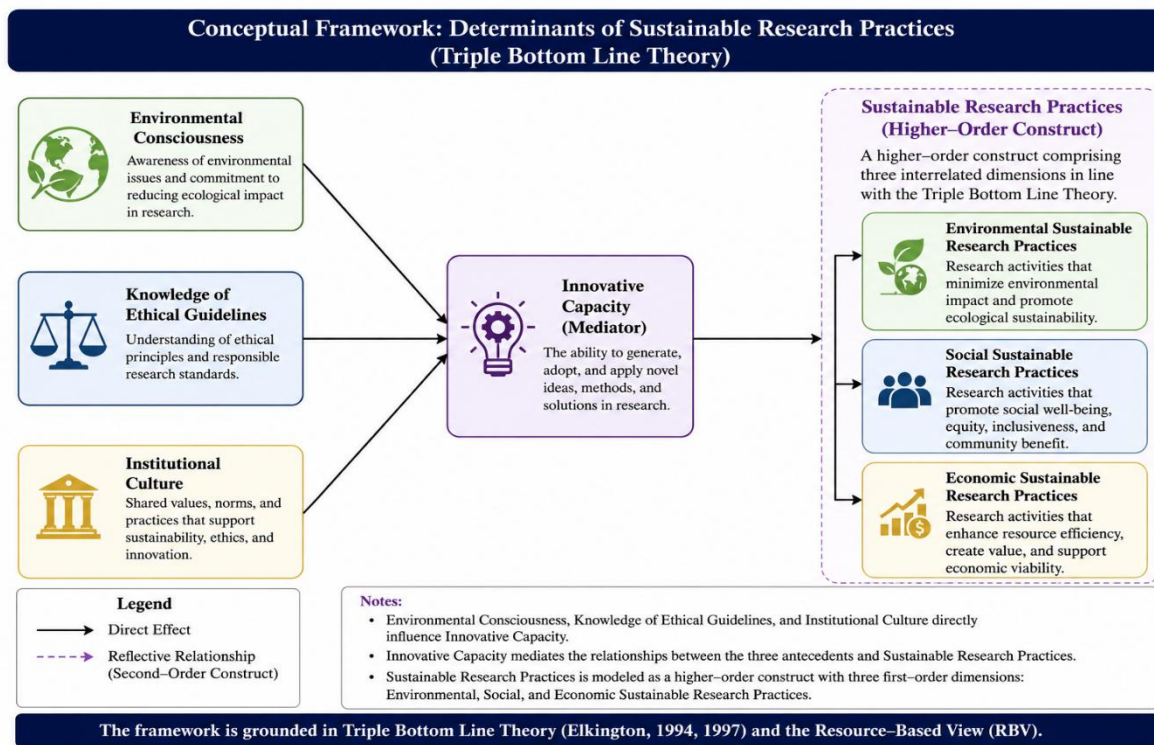
3. Conceptual / Theoretical framework

The proposed conceptual framework explores the relationship between environmental consciousness, knowledge of ethical guidelines, institutional culture, and sustainable research practices, with innovative capacity serving as a mediator, as illustrated in Figure 1. Within the context of higher education research, sustainable research practices are therefore conceptualized as a higher-order construct comprising three interrelated dimensions: environmental sustainability, social responsibility, and economic sustainability. Rather than functioning as independent outcomes, these three dimensions collectively represent the broader construct of sustainable research practices.

Environmental consciousness refers to an awareness of environmental issues and the role research plays in addressing these challenges. Researchers who are more environmentally conscious are more likely to adopt practices that reduce ecological impact. Knowledge of ethical guidelines ensures that research adheres to responsible standards, safeguarding human participants and minimizing environmental harm. Institutional culture plays a critical role in shaping how both environmental consciousness and ethical guidelines are applied. Institutions that prioritize sustainability and ethical conduct create an environment that supports socially responsible, environmentally sustainable, and economically viable research. A robust culture of innovation and collaboration aligns research efforts with the Sustainable Development Goals (SDGs), fostering sustainable practices across all areas.

Figure 1

Proposed Research Model Illustrating the Relationships among the Study Variables



Note. This framework is grounded in John Elkington's Triple Bottom Line (TBL) Theory (1994; 1997), which posits that sustainability is achieved through the balanced integration of environmental, social, and economic outcomes.

The mediating role of innovative capacity is theoretically supported by the Triple Bottom Line framework. First, environmental consciousness is expected to enhance innovative capacity because individuals and institutions that recognize environmental challenges are more likely to seek creative research methods, sustainable technologies, and innovative solutions that minimize environmental impact while improving research effectiveness. Environmental awareness therefore stimulates innovation by encouraging researchers to rethink conventional research practices in favour of more sustainable alternatives.

Second, knowledge of ethical guidelines contributes to innovative capacity by providing a framework within which innovation can occur responsibly. Ethical knowledge promotes transparency, accountability, integrity, and responsible decision-making, thereby encouraging innovations that are socially acceptable and sustainable. Although ethical regulations may constrain certain research practices by imposing procedural requirements, they simultaneously strengthen innovation by ensuring that new ideas are developed within acceptable ethical boundaries, thereby increasing public trust and long-term sustainability.

Third, institutional culture influences innovative capacity because organizational environments that encourage collaboration, interdisciplinary research, leadership support, continuous learning, and resource availability create favourable conditions for innovation. Institutions that value creativity and sustainability are more likely to provide researchers with opportunities, incentives, infrastructure, and support systems necessary for developing innovative research approaches. Conversely, rigid institutional cultures may inhibit innovation and reduce researchers' willingness to adopt sustainable research practices.

Innovative capacity subsequently translates these institutional and individual attributes into sustainable research practices. Researchers with higher innovative capacity are better positioned to develop environmentally responsible research procedures, utilise resources efficiently, adopt socially inclusive research approaches, and generate economically viable research solutions. Consequently, innovative capacity functions as the mechanism through which environmental consciousness, ethical knowledge, and institutional culture are transformed into sustainable

research practices across the environmental, social, and economic dimensions proposed by the Triple Bottom Line theory.

Accordingly, the present study conceptualizes Sustainable Research Practices as a second-order (higher-order) latent construct reflected by three first-order dimensions: Environmental Sustainable Research Practices, Social Sustainable Research Practices, and Economic Sustainable Research Practices. This conceptualization is theoretically consistent with the Triple Bottom Line framework and provides a more parsimonious representation of sustainability within higher education research.

Researchers with high innovative capacity can develop novel solutions to sustainability challenges, integrating them into research design and outcomes. The TBL theory underscores the importance of integrating all three sustainability pillars in research, encouraging researchers to focus not only on academic or financial outcomes but also on broader societal, economic, and environmental impacts. Thus, the following hypotheses were raised for the study.

H1: Environmental consciousness positively influences economic sustainable research practices.

H2: Environmental consciousness positively influences environmentally sustainable research practices.

H3: Environmental consciousness positively influences social sustainable research practices.

H4: Environmental consciousness positively influences innovative capacity.

H5: Knowledge of ethical guidelines positively influences environmentally sustainable research practices.

H6: Knowledge of ethical guidelines positively influences economic sustainable research practices.

H7: Knowledge of ethical guidelines positively influences social sustainable research practices.

H8: Knowledge of ethical guidelines positively influences innovative capacity.

H9: Innovative capacity positively influences environmentally sustainable research practices.

H10: Innovative capacity positively influences economic sustainable research practices.

H11: Innovative capacity positively influences social sustainable research practices.

H12: Institutional culture positively influences environmentally sustainable research practices.

H13: Institutional culture positively influences economic sustainable research practices.

H14: Institutional culture positively influences social sustainable research practices.

H15: Institutional culture positively influences innovative capacity.

H16: Innovative capacity positively mediates the relationship between environmental consciousness and sustainable research practices (environmental, economic, and social).

H17: Innovative capacity positively mediates the relationship between knowledge of ethical guidelines and sustainable research practices (environmental, economic, and social).

H18: Innovative capacity positively mediates the relationship between institutional culture and sustainable research practices (environmental, economic, and social).

4. Methodology

The study followed a positivist research paradigm, heavily relying on quantitative analysis. A cross-sectional research design was chosen to gather data from a large sample of respondents at a specific point in time, with the aim of generalizing the findings to a broader population (Ofem, 2024a, 2024b, 2024d, 2024e, 2024f). The research utilized a quantitative methodology and a cross-sectional survey design, collecting data from a diverse group of participants within a set time frame through various channels (Ofem et al., 2024c, 2024d, 2024e). The target population consisted of 2,892 full-time academic staff actively engaged in teaching and research from the five selected public universities included in the study. Although participants were drawn from diverse academic disciplines, including Pure Sciences, Agriculture, Humanities, Arts, and Social Sciences, these disciplines were not treated as sampling clusters but rather represented the academic backgrounds of the respondents. A multistage sampling procedure was employed. In the first stage, the five universities were purposively selected because of their active research environments and postgraduate programmes. Each university constituted one institutional cluster. In the second

stage, a sample representing approximately 50% of the academic staff population within each university was proportionately allocated to ensure adequate representation. This resulted in a planned sample size of 1,446 participants. The distribution of the planned sample across the institutional clusters was as follows: Cluster 1 (University 1, $n = 422$), Cluster 2 (University 2, $n = 232$), Cluster 3 (University 3, $n = 343$), Cluster 4 (University 4, $n = 347$), and Cluster 5 (University 5, $n = 102$). Demographic analysis showed that 732 respondents (50.62%) were male, while 714 (49.38%) were female. The age distribution was as follows: 654 participants (45.23%) were under 40 years, 659 (45.57%) were between 40 and 60 years, and 133 (9.19%) were over 60 years. In terms of academic disciplines, 422 (29.18%) were in Pure Science, 232 (16.04%) in Agriculture, 343 (23.72%) in Humanities, 347 (23.80%) in Social Science, and 102 (7.05%) in Arts.

4.1. Instruments

The study focused on seven constructs, namely environmental consciousness, knowledge of ethical guidelines, institutional culture, innovative capacity, and three dimensions of sustainable research practices: environmental, social, and economic sustainability. The research instrument was specifically developed for this study following an extensive review of the literature, focus group discussions with experienced researchers, and consultations with experts in research methodology, sustainability, and higher education. This systematic development process ensured that the questionnaire adequately captured the theoretical constructs investigated in the study and reflected the context of sustainable research practices within Nigerian higher education institutions.

The research instrument was divided into three sections. Section A collected demographic information, including gender, age, and academic discipline, using categorical response options. It also contained the participant information sheet and electronic informed consent statement, which participants completed before accessing the questionnaire. Email addresses and telephone numbers were requested solely to verify participant eligibility and identify duplicate submissions during data screening. These identifiers were removed before analysis to preserve participants' anonymity and confidentiality.

Section B measured the explanatory variables. Environmental consciousness, which refers to awareness of environmental issues and the impact of human activities, was initially measured with six items, including *"I actively seek out sustainable methods and materials when conducting research."* Knowledge of ethical guidelines, which reflects understanding of the principles and standards governing responsible research, was initially measured with six items, including *"I am familiar with the ethical guidelines related to conducting research in my field."* Institutional culture, which represents the shared values, practices, and norms that support research, was initially measured with six items, with a sample item being *"My institution provides sufficient resources to support high-quality research."* Innovative capacity, defined as the ability to generate and implement new ideas and solutions, was also initially measured with six items, including *"I am encouraged to generate new ideas related to my work."* All items were measured using a four-point Likert scale: 4 = Strongly Agree, 3 = Agree, 2 = Disagree, and 1 = Strongly Disagree, with higher scores indicating stronger agreement with the measured construct. No negatively worded or reverse-coded items were included in the questionnaire. This section initially comprised 24 items.

Section C measured the three dimensions of sustainable research practices. Environmental sustainable research practices, which involve the adoption of environmentally responsible research behaviours, were initially measured with six items, including *"I actively consider the environmental impact of my research activities."* Social sustainable research practices, which relate to ensuring that research benefits society and contributes to equitable development, were initially measured with six items, including *"My research activities actively engage local communities or social groups to ensure their relevance and benefits."* Economic sustainable research practices, which concern the efficient and responsible use of research resources, were initially measured with six items, including *"My research activities are designed to maximize the efficient use of financial resources."* This section initially consisted of 18 items, giving an initial total of 42 items across the seven constructs.

4.2. Content Validity

The validation of the scale items followed a rigorous quantitative process, involving a panel of five experts from various academic fields. These experts evaluated the relevance, clarity, and appropriateness of the items in relation to the study's constructs. The 42 items were initially developed through a comprehensive literature review and adaptation from previous studies. After the initial screening, six items were discarded. The experts used a structured questionnaire and an evaluation rubric, adhering to standard guidelines for content validity (Ofem et al., 2024a, 2024b). Each item was rated on a four-point scale, with 1 indicating irrelevance and 4 indicating high relevance. The Item-Content Validity Index (I-CVI) was then calculated to assess the suitability of each item, with values ranging from 0 to 1. An I-CVI of 0.78 or higher is generally considered acceptable, indicating strong agreement among the expert panel about an item's relevance and clarity. In some cases, especially when the panel is small or the item development criteria are particularly stringent, values as low as 0.70 may be deemed acceptable (Polit & Beck, 2006).

For the Scale-Level Content Validity Index (S-CVI), two methods were applied: the Average Method (S-CVI/Ave), which calculates the average relevance score for all items, with a score of 0.80 or above typically signifying strong content validity, and the Universal Agreement Method (S-CVI/UA), which evaluates the percentage of items rated as relevant by all experts. The I-CVI values for this study ranged from 0.80 to 0.98 for the assessed criteria, while the S-CVI values ranged from 0.90 to 0.97, indicating that the instrument had high relevance and clarity (DeVellis, 2016; Polit & Beck, 2006). As a result of these evaluations, eleven items were deemed unsuitable and excluded, leaving the instrument with a total of 32 items. To further assess the instrument's reliability, internal consistency was tested using responses from a pilot group of 150 staff members who were not part of the main study. The results of the validity and reliability assessments are presented in Table 1.

4.3. Procedure for data collection

Data collection was conducted in accordance with established ethical principles for research involving human participants. Although the Nigerian Code for Health Research Ethics permits a waiver of informed consent for minimal-risk survey research, electronic informed consent was obtained from all participants before they accessed the online questionnaire. The study protocol received ethical approval from the Institutional Review Board of Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State, Nigeria (Approval No. IRB/FUNAI/0132/0809). The introductory section of the questionnaire informed participants about the purpose of the study, the voluntary nature of participation, confidentiality of the information provided, and their right to withdraw from the study at any stage without any consequences. Participants indicated their consent electronically before completing the questionnaire.

Ten research assistants were recruited from professional colleagues within the participating universities and received modest financial compensation for their assistance. Before data collection, they were trained through a dedicated Telegram platform on the study protocol, ethical requirements, participant eligibility criteria, and standardized procedures for questionnaire administration. The research assistants identified and administered the questionnaire through 43 verified WhatsApp groups comprising academic staff from the five participating universities. The WhatsApp groups were identified through faculty representatives, departmental administrators, and recognized academic associations within the selected institutions to ensure that only eligible academic staff were included. Only full-time academic staff actively engaged in teaching and research were invited to participate.

A total of 1,446 questionnaires were distributed through the 43 verified academic staff WhatsApp groups. To minimize duplicate submissions, the Google Forms questionnaire was configured to allow only one submission per participant, and the completed dataset was further screened for duplicate entries and inconsistent response patterns before analysis. Of the

Table 1

Quantitative content validity indices and Cronbach reliability estimates of the variables in the instrument used for data collection

<i>Variables</i>	<i>N</i>	<i>I-CVI S</i>	<i>I-CVI R</i>	<i>I-CVI P</i>	<i>S-CVI S</i>	<i>S-CVI R</i>	<i>S-CVI P</i>	<i>α</i>
Environmental consciousness	5	.78-.81	.80-.91	.78-.83	.91	.97	.80	.87
Knowledge of ethical guidelines	5	.79-.84	.81-.95	.80-.88	.90	.84	.94	.84
Institutional culture	4	.85-.91	.80-.89	.78-.89	.92	.89	.94	.90
Innovative capacity	4	.82-.99	.85-.93	.85-.89	.93	.93	.92	.83
Environmental sustainability	5	.84-.90	.79-.88	.78-.96	.92	.92	.91	.82
Social sustainability	3	.79-.87	.83-.89	.84-.94	.92	.93	.94	.90
Economic sustainability	5	.81-.95	.81-.97	.86-.97	.98	.97	.95	.84

Note. I-CVCS: Item Content Validity Index for Suitability, I-CVI R: Item Content Validity Index for Relevance, I-CVI P: Item Content Validity Index for Precision, S-CVIS: Scale Content Validity Index for suitability, S-CVI R Scale Content Validity Index for Relevance, S-CVI P Scale Content Validity Index for Precision, α = Cronbach Alpha reliability estimate.

questionnaires distributed, 1,421 (98.3%) were completed and returned. Following data screening, 10 questionnaires (0.7%) were excluded because they contained substantial missing data, incomplete responses, or inconsistent response patterns that rendered them unsuitable for Partial Least Squares Structural Equation Modelling (PLS-SEM). Consequently, 1,411 questionnaires (97.6% of the questionnaires distributed and 99.3% of those returned) were complete and valid and therefore constituted the final dataset used for all statistical analyses.

5. Results

5.1. Model Evaluation

The evaluation of the model focused on assessing the item loadings for each construct to ensure their quality. Research suggests that item loadings greater than 0.70 are generally considered ideal (Ofem et al., 2024d). As indicated in Table 2, most item loadings exceed this threshold, with the exceptions of SOS1, ECO 5, ECO 2, INST3, and INST6. While these lower loadings do not meet the preferred standard, they may still be retained if the construct demonstrates overall validity and reliability (Hair et al., 2019) and meets content validity requirements (Diamantopoulos et al., 2012). Empirical studies suggest that items with minor deviations can be retained as long as the overall model fit remains intact, particularly in exploratory research (Henseler et al., 2009). Retaining such items can also help preserve the conceptual framework, provided there is adequate theoretical justification (Hair et al., 2019). Nevertheless, future research should revalidate or reconsider these items.

At the scale level, Cronbach's alpha values for all constructs were above 0.70, indicating strong internal consistency. Convergent validity was assessed through the average variance extracted (AVE), with values of 0.50 or higher considered sufficient (Ofem et al., 2024g). As shown in Table 3, all constructs achieved convergent validity. Discriminant validity was ensured by limiting excessive correlations between unrelated constructs. This was evaluated using the Fornell-Larcker criterion (Fornell & Larcker, 1981), which compares the square root of each construct's AVE with its correlations with other constructs (Ofem et al., 2024c, 2024d). This statistical method, designed for structural equation modelling (SEM), confirms that constructs are distinct within the model. Table 3 demonstrates that discriminant validity was achieved, as the square root of each construct's AVE exceeds the correlations with other constructs.

To assess predictive relevance, potential collinearity within the structural model was first examined. Table 2 shows that the outer variance inflation factors (VIFs) for all constructs were below the recommended threshold of 5.00 (Hair et al., 2017), with values ranging from 1.44 to 4.46. The inner model VIFs also remained below 5.00, ranging from 1.00 to 1.08, indicating no significant collinearity among predictors. The model's in-sample predictive accuracy was evaluated by examining the proportion of variance explained by exogenous variables in the endogenous variables. Table 2 reveals that environmental consciousness, knowledge of ethical guidelines, and institutional culture together explained 7.5% ($R^2 = 0.075$) of the variance in innovative capacity among academic staff. These factors, along with innovative capacity, accounted for 2.4% ($R^2 = 0.024$) of the variance in environmental sustainability. For economic sustainability, these four factors together accounted for 9.7% ($R^2 = 0.097$), while for social sustainability, they accounted for 39.8% ($R^2 = 0.398$). This suggests that these factors contribute more to social and economic sustainability than to environmental sustainability.

Predictive accuracy below 10% is generally considered weak (Hair et al., 2019). However, the relatively low R^2 values observed for environmental and economic sustainability reflect the complexity of behavioral models, where various psychological, individual, and institutional factors interact to influence endogenous variables. To assess out-of-sample predictive performance, the PLSpredict method was applied with 10 folds and a single repetition. This method simulates real-world PLS modelling applications by using separate training and holdout samples to independently estimate model parameters and evaluate predictive accuracy (Sharma et al., 2023).

Table 2
Quality checks of the items

Items	α	CR	AVE	EFA	VIF	R^2	Q^2
ECC1				0.913	2.296		
ECC2				0.893	2.455		
ECC4				0.804	2.444		
ECC5				0.895	1.051		
ECC6				0.859	3.364		
Environmental consciousness	.923	.942	.763				
ECO1				0.941	1.336		
ECO2				0.688	2.348		
ECO3				0.926	4.168		
ECO5				0.591	1.981		
ECO6				0.896	3.154		
Economic sustainability	.883	.909	.674			.097	0.093
ENV1				0.72	1.580		
ENV2				0.901	3.428		
ENV4				0.889	3.236		
ENV5				0.756	2.136		
ENV6				0.738	2.136		
Environmental sustainability	.862	.901	.647			0.024	0.021
ETH1				0.918	2.239		
ETH2				0.889	4.526		
ETH3				0.977	1.742		
ETH4				0.954	2.041		
ETH5				0.866	4.368		
Ethical guidelines	.955	.966	.849				
ICV1				0.822	1.88		
ICV2				0.796	1.933		
ICV3				0.838	1.974		
ICV4				0.884	2.239		
Innovative Capacity	.857	.902	.698			0.075	0.073
INST1				0.778	2.675		
INST3				0.611	1.692		
INST5				0.901	2.345		
INST6				0.664	1.16		
Institutional Culture	.753	.832	.558				
SOS1				0.544	1.194		
SOS3				0.981	2.137		
SOS5				0.979	2.104		
Social Sustainability	.811	.889	.739			0.398	0.377

Note. ENV=Environmental sustainability, ETH=Ethical guidelines, ICV=Innovative capacity, INST=Institutional culture; SOS=Social sustainability, Eco=Economic sustainability, ECC=Environmental consciousness

The dataset was divided into a training subset to estimate key parameters and a holdout subset for validating predictions. Parameters derived from the training subset were then used to predict the indicators of dependent constructs (Shmueli et al., 2019). This approach allowed for a comprehensive evaluation of prediction accuracy at both the indicator and composite score levels, ensuring a complete assessment of the model's predictive capabilities. The Q^2 values obtained through the PLSpredict process ranged from 0.07 to 0.39, all positive and greater than zero (see Table 4). A Q^2 value above zero indicates sufficient reconstruction, confirming the model's

predictive relevance. Additionally, a positive Q^2 value shows that the predictive error in PLS-SEM is lower than that of using mean values alone, highlighting the superior predictive performance of PLS-SEM (Hair et al., 2022; Shmueli et al., 2019).

A thorough analysis of prediction errors was performed to determine key prediction metrics. As shown in Figure 2, the errors in PLS-SEM predictions did not follow a normal distribution. To address this asymmetry, the mean absolute error (MAE) was used instead of the root mean squared error (RMSE) to assess the model's predictive accuracy, in line with the asymmetric distributions shown in Figure 2. The results indicated that PLS-SEM yielded similar outcomes to the linear model (LM) approach for many items. However, slightly higher MAEs were noted for certain items under the PLS-SEM model, with differences ranging from 0.03 to 0.05, though these differences were not statistically significant. Since the PLS-SEM model includes a mediating variable that the LM model does not, these minor increases in MAE may indicate the improved predictive performance of the PLS-SEM model. This interpretation is further supported by the strong results from all other quality criteria (Shmueli et al., 2019).

Table 3

Predictive model fit assessment using the MAEs derived from the PLS-SEM and LM procedures

PLS	MAE	$Q^2_{predict}$	MAE	$Q^2_{predict}$	D
ECO1	0.492	0.096	0.484	0.102	0.008
ECO2	0.648	0.001	0.643	0.029	0.005
ECO3	0.476	0.097	0.464	0.104	0.012
ECO5	0.676	0.005	0.672	0.02	0.004
ECO6	0.503	0.083	0.493	0.091	0.010
ENV1	0.629	0.012	0.596	0.063	0.033
ENV2	0.614	0.02	0.574	0.094	0.040
ENV4	0.657	0.022	0.628	0.059	0.029
ENV5	0.669	0.004	0.638	0.057	0.031
ENV6	0.691	0.007	0.673	0.03	0.018
ICV1	0.601	0.039	0.577	0.088	0.024
ICV2	0.66	0.01	0.638	0.073	0.022
ICV4	0.575	0.086	0.554	0.143	0.021
ICV3	0.635	0.056	0.595	0.129	0.040
SOS1	0.73	0.017	0.733	0.071	-0.003
SOS3	0.309	0.38	0.261	0.466	0.048
SOS5	0.3	0.411	0.241	0.504	0.059

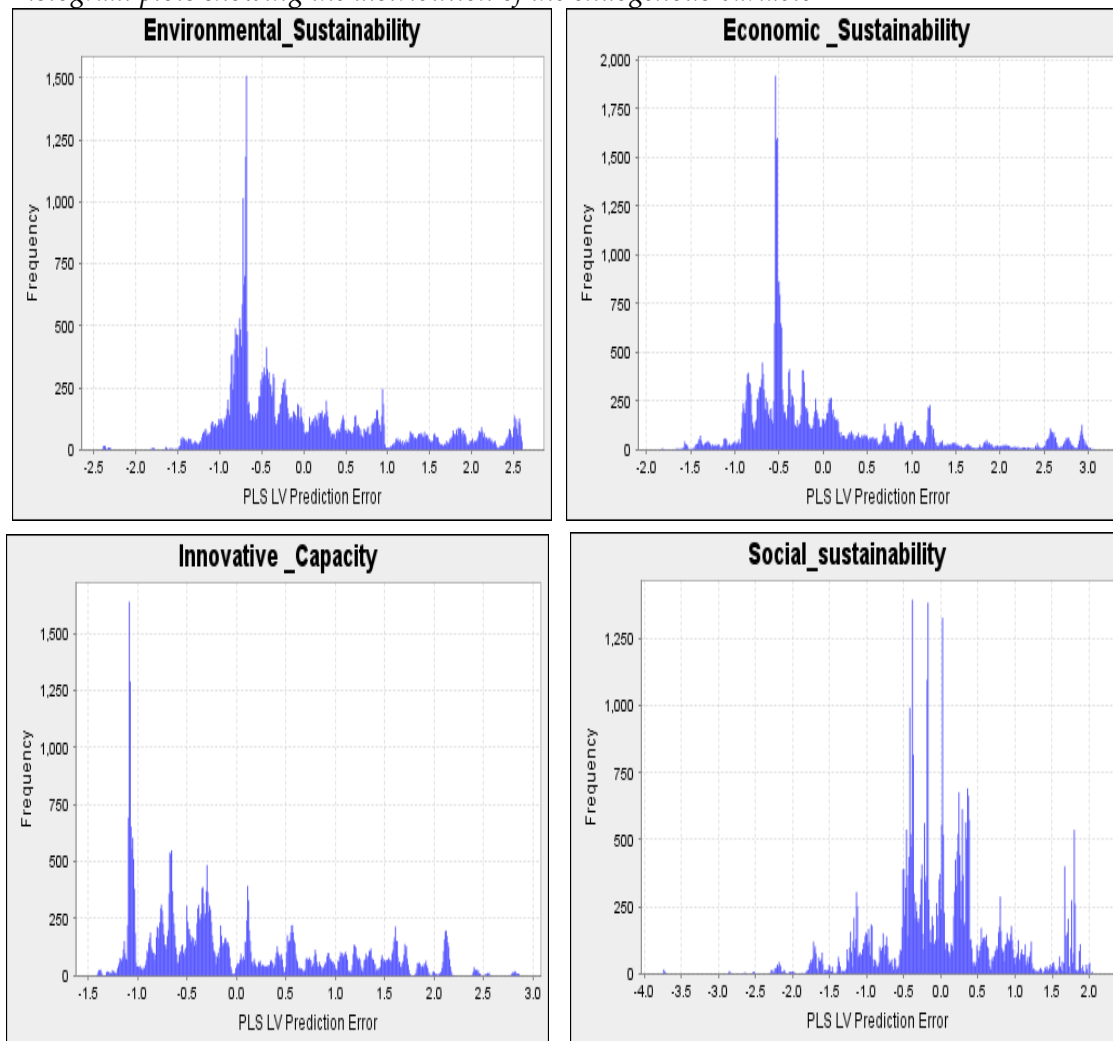
5.2. Structural Model and Test of Hypotheses

5.2.1. Structural equation modelling

Direct Effects. The results presented in Figure 3 and Table 4 show that H1 was supported, as environmental consciousness had a significant positive direct effect on economic sustainable research practices ($\beta = 0.155$, $t = 9.988$, $p < .001$). However, H2 was not supported, as environmental consciousness did not have a significant direct effect on environmentally sustainable research practices ($\beta = 0.019$, $t = 1.048$, $p = .295$). H3 was supported, indicating that environmental consciousness had a significant positive direct effect on social sustainable research practices ($\beta = 0.629$, $t = 57.284$, $p < .001$). Likewise, H4 was supported, showing that environmental consciousness significantly and positively influenced innovative capacity ($\beta = 0.098$, $t = 5.205$, $p < .001$). These findings indicate that environmental consciousness significantly predicts economic and social sustainable research practices, as well as innovative capacity, but does not significantly predict environmentally sustainable research practices.

Figure 2

Histogram plots showing the distribution of the endogenous variable



The results further showed that H5, H6, H7, and H8 were supported. Knowledge of ethical guidelines had a significant positive direct effect on environmental sustainable research practices ($\beta = 0.151$, $t = 9.150$, $p < .001$) and economic sustainable research practices ($\beta = 0.236$, $t = 13.497$, $p < .001$). It also had significant negative direct effects on social sustainable research practices ($\beta = -0.165$, $t = 11.620$, $p < .001$) and innovative capacity ($\beta = -0.288$, $t = 23.171$, $p < .001$). These findings indicate that although greater knowledge of ethical guidelines enhances environmental and economic sustainable research practices, it is associated with lower levels of social sustainable research practices and innovative capacity.

The findings also revealed that H9, H10, and H11 were supported. Innovative capacity exerted a significant positive direct effect on environmental sustainable research practices ($\beta = 0.038$, $t = 2.309$, $p = .021$) and economic sustainable research practices ($\beta = 0.050$, $t = 3.313$, $p = .001$). Conversely, innovative capacity had a significant negative direct effect on social sustainable research practices ($\beta = -0.147$, $t = 11.880$, $p < .001$). These findings demonstrate that innovative capacity significantly influences all three dimensions of sustainable research practices, although the direction of its influence differs across dimensions.

Finally, the results showed that H12, H13, and H14 were supported, whereas H15 was not supported. Institutional culture had a significant positive direct effect on environmental sustainable research practices ($\beta = 0.061$, $t = 2.978$, $p = .003$) and social sustainable research practices ($\beta = 0.063$, $t = 6.011$, $p < .001$). It also had a significant negative direct effect on economic sustainable research practices ($\beta = -0.031$, $t = 2.036$, $p = .042$). However, institutional culture did not have a significant direct effect on innovative capacity ($\beta = -0.025$, $t = 1.570$, $p = .117$). Therefore,

institutional culture significantly predicts environmental, economic, and social sustainable research practices but does not significantly predict innovative capacity.

Table 4

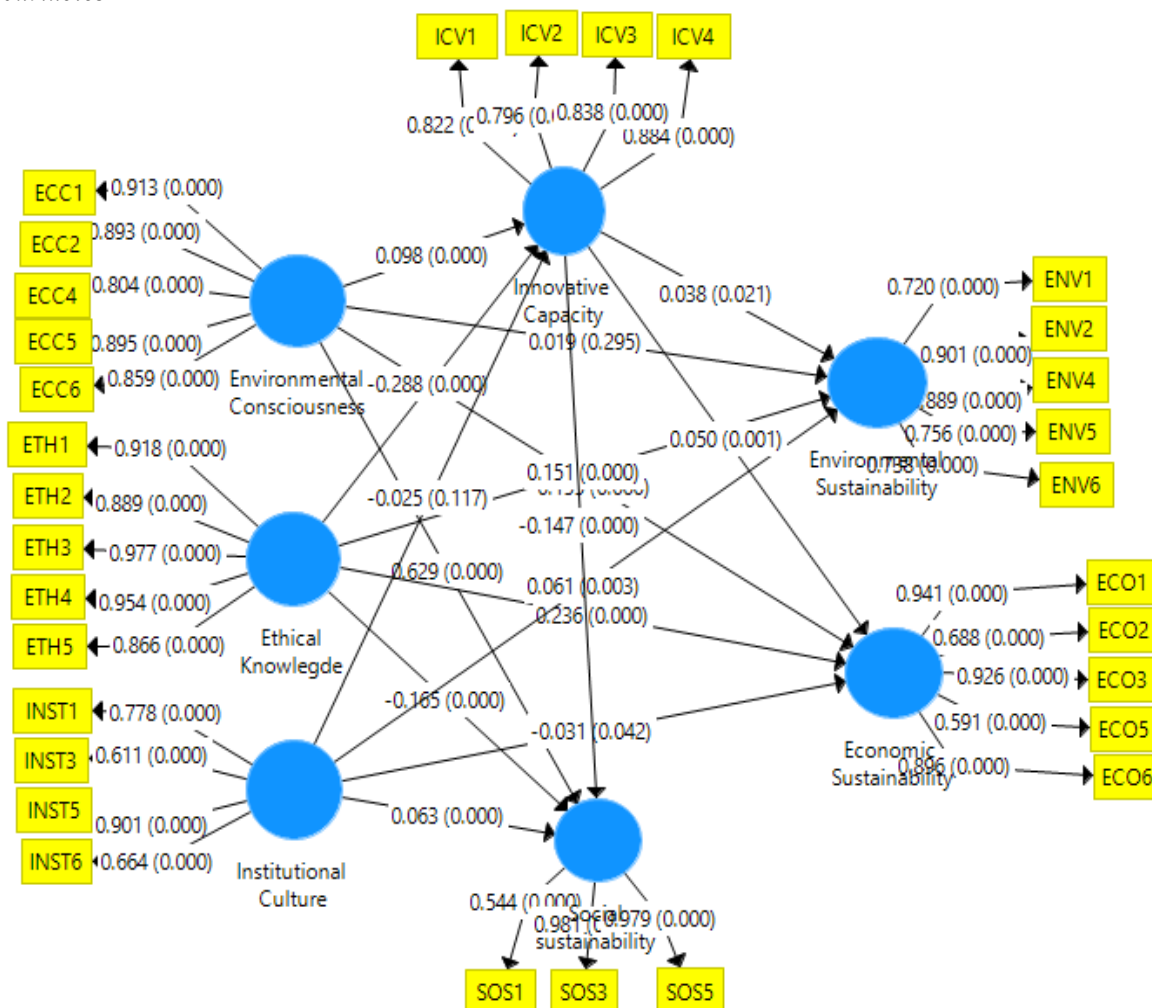
Direct effect

LINKAGES	β	5%	95%	M	SD	t-cal	p-val	Remark
ECC → ECO	0.155	0.124	0.184	0.155	0.016	9.988	0.000	Supported
ECC → ENV	0.019	-0.015	0.055	0.018	0.018	1.048	0.295	
ECC → ICV	0.098	0.059	0.133	0.098	0.019	5.205	0.000	Supported
ECC → SOS	0.629	0.607	0.650	0.629	0.011	57.284	0.000	Supported
ETH → ECO	0.236	0.203	0.270	0.235	0.017	13.497	0.000	Supported
ETH → ENV	0.151	0.117	0.18	0.152	0.016	9.15	0.000	Supported
ETH → ICV	-0.288	-0.312	-0.263	-0.288	0.012	23.171	0.000	Supported
ETH → SOS	-0.165	-0.194	-0.138	-0.165	0.014	11.62	0.000	Supported
ICV → ECO	0.05	0.017	0.078	0.050	0.015	3.313	0.001	Supported
ICV → ENV	0.038	0.000	0.068	0.040	0.017	2.309	0.021	Supported
ICV → SOS	-0.147	-0.169	-0.123	-0.148	0.012	11.88	0.000	Supported
INST → ECO	-0.031	-0.060	-0.001	-0.031	0.015	2.036	0.042	Supported
INST → ENV	0.061	0.021	0.101	0.061	0.021	2.978	0.003	Supported
INST → IVC	-0.025	-0.054	0.001	-0.025	0.016	1.570	0.117	
INST → SOC	0.063	0.045	0.084	0.064	0.011	6.011	0.000	Supported

Note. M=Mean, SD=Standard deviation, CI=Confidence interval

Figure 3

Structural equation model of the linkages between the explanatory and criterion variable before mediating variables



Indirect Effects (Mediation Analysis). The mediation results presented in Figure 3 and Table 5 indicate that H16 was partially supported. Innovative capacity significantly mediated the relationship between environmental consciousness and economic sustainable research practices ($\beta = 0.005$, $t = 2.667$, $p = .008$), environmentally sustainable research practices ($\beta = 0.004$, $t = 2.187$, $p = .029$), and social sustainable research practices ($\beta = -0.014$, $t = 5.175$, $p < .001$). The indirect effects on economic and environmental sustainable research practices were positive, whereas the indirect effect on social sustainable research practices was negative. Although these mediation effects were statistically significant, the standardized indirect effects ($\beta = 0.004$ – 0.014) were very small, suggesting limited practical significance. Because both the direct and indirect effects were significant, the mediation is interpreted as partial mediation.

The results further showed that H17 was partially supported. Innovative capacity significantly mediated the relationship between knowledge of ethical guidelines and economic sustainable research practices ($\beta = -0.014$, $t = 3.317$, $p = .001$), environmentally sustainable research practices ($\beta = -0.011$, $t = 2.283$, $p = .023$), and social sustainable research practices ($\beta = 0.042$, $t = 10.397$, $p < .001$). The mediation effects on economic and environmental sustainable research practices were negative, whereas the indirect effect on social sustainable research practices was positive. Similar to the previous findings, the statistically significant indirect effects were relatively small in magnitude, indicating modest practical importance. Since significant direct effects also existed between knowledge of ethical guidelines and the outcome variables, the mediation is classified as partial mediation.

For H18, the results revealed that innovative capacity did not significantly mediate the relationship between institutional culture and economic sustainable research practices ($\beta = -0.001$, $t = 1.367$, $p = .172$), environmentally sustainable research practices ($\beta = -0.001$, $t = 1.189$, $p = .235$), or social sustainable research practices ($\beta = 0.004$, $t = 1.546$, $p = .123$). The 95% confidence intervals for these indirect effects included zero, indicating the absence of statistically significant mediation. Therefore, H18 was not supported, suggesting that innovative capacity does not function as a mediator in the relationship between institutional culture and the three dimensions of sustainable research practices.

Table 5

Indirect effect

<i>Path</i>	β	<i>LLCI</i>	<i>ULCI</i>	<i>t</i>	<i>p</i>	<i>Decision</i>
ECC → ICV → ECO	0.005	0.002	0.009	2.667	.008	Supported
ECC → ICV → ENV	0.004	0.001	0.007	2.187	.029	Supported
ECC → ICV → SOC	-0.014	-0.020	-0.009	5.175	< .001	Supported
ETH → ICV → ECO	-0.014	-0.022	-0.005	3.317	.001	Supported
ETH → ICV → ENV	-0.011	-0.019	-0.001	2.283	.023	Supported
ETH → ICV → SOC	0.042	0.035	0.050	10.397	< .001	Supported
INST → ICV → ECO	-0.001	-0.003	0.000	1.367	.172	Not Supported
INST → ICV → ENV	-0.001	-0.003	0.000	1.189	.235	Not Supported
INST → ICV → SOC	0.004	0.000	0.008	1.546	.123	Not Supported

Note. M=Mean, SD=Standard deviation, CI=Confidence interval

6. Discussion

The findings of this study demonstrate that sustainable research practices among academic staff are influenced by a combination of environmental consciousness, knowledge of ethical guidelines, institutional culture, and innovative capacity. However, the results also reveal that these relationships are neither uniformly positive nor consistently significant, suggesting that sustainable research behaviour in Nigerian higher education is shaped by both individual and institutional factors.

The study found that environmental consciousness significantly predicted economic and social sustainable research practices but did not significantly predict environmentally sustainable research practices. The positive relationship with economic sustainability suggests that researchers

who are environmentally conscious are more likely to adopt resource-efficient research approaches, minimize waste, and utilize available research resources responsibly. This finding supports the proposition of John Elkington that environmental responsibility contributes not only to ecological outcomes but also to long-term economic efficiency. Similarly, the positive association between environmental consciousness and social sustainable research practices indicates that environmentally aware researchers are more likely to consider the societal implications of their research through responsible knowledge production, collaboration, and inclusive research practices. This finding agrees with Anita Kollmuss and Julian Agyeman (2002), who reported that individuals with stronger environmental awareness are generally more inclined to adopt sustainable behaviours. It is also consistent with Niklas Gericke et al. (2019), who found that sustainability consciousness positively influences sustainability-oriented actions among higher education stakeholders.

Contrary to expectations, environmental consciousness did not significantly influence environmentally sustainable research practices. This finding contrasts with the assumption that environmental awareness automatically translates into environmentally responsible behaviour. A plausible explanation is the existence of the value-action gap described by Kollmuss and Agyeman (2002), whereby individuals may possess strong environmental values but remain unable to implement them because of contextual constraints. Within Nigerian universities, inadequate funding, limited laboratory infrastructure, weak institutional environmental policies, and insufficient access to green research technologies may prevent researchers from translating environmental awareness into environmentally sustainable research practices. This finding is further supported by the Theory of Planned Behavior, which argues that behavioural intentions alone are insufficient without perceived behavioural control and enabling conditions (Ajzen, 1991).

The results further revealed that knowledge of ethical guidelines significantly influenced all three dimensions of sustainable research practices and innovative capacity, although the directions of these relationships differed. Ethical knowledge positively predicted environmental and economic sustainable research practices, suggesting that researchers who possess greater understanding of research ethics are more likely to conduct environmentally responsible and economically efficient research. These findings support the argument that ethical principles encourage accountability, transparency, responsible resource utilization, and long-term stewardship, which are central to sustainable research. Similar observations have been reported by Rodrigo Lozano et al. (2015), who concluded that institutional commitment to sustainability requires ethical governance and responsible research practices, and by Walter Leal Filho et al. (2019), who emphasized that sustainability in higher education depends on embedding ethical and sustainability principles into research and teaching.

However, knowledge of ethical guidelines showed significant negative relationships with innovative capacity and social sustainable research practices. These findings deserve careful interpretation rather than being viewed as contradictory. One possible explanation is that researchers who focus heavily on procedural compliance may become more risk-averse, thereby reducing their willingness to explore unconventional or innovative research approaches. Extensive ethical review procedures, administrative requirements, and regulatory compliance may inadvertently discourage experimentation and delay innovation. Similarly, an emphasis on procedural compliance may reduce researchers' attention to broader social engagement activities, including participatory research and community collaboration. Although unexpected, these findings highlight the need for ethics education that balances regulatory compliance with creativity, collaboration, and socially responsive research.

Innovative capacity also demonstrated mixed effects on sustainable research practices. The positive effects on environmental and economic sustainability suggest that innovative researchers are more capable of developing environmentally responsible methodologies, improving research efficiency, and optimizing the use of available resources. These findings are consistent with L. Schaap et al. (2025), who concluded that innovation capacity is fundamental to institutional sustainability because it enables universities to respond effectively to emerging societal and

environmental challenges. Likewise, Stephen Bell (2010) and Paul C. Blumenfeld et al. (1991) argued that innovation promotes creative problem-solving and practical application of knowledge, thereby improving sustainable outcomes.

Conversely, innovative capacity exerted a significant negative effect on social sustainable research practices. This result suggests that innovation alone may not necessarily promote socially inclusive research. Within many Nigerian universities, innovation is frequently evaluated through publication outputs, patents, and technological advancement rather than community engagement or societal impact. Consequently, researchers may prioritize technological innovation while paying comparatively less attention to participatory research and stakeholder involvement. This finding underscores the importance of aligning innovation policies with the broader objectives of social sustainability.

Institutional culture significantly predicted environmental, social, and economic sustainable research practices but did not significantly predict innovative capacity. The significant relationships indicate that supportive institutional environments encourage responsible research conduct and sustainable resource management. These findings agree with Thomas S. A. Wright (2010), who reported that leadership commitment and institutional values strongly influence sustainability implementation in universities, and with Rodrigo Lozano (2011), who found that institutional sustainability reporting reflects organizational commitment to sustainable practices. However, the absence of a significant relationship between institutional culture and innovative capacity suggests that supportive organizational values alone are insufficient to stimulate innovation. Innovation also requires research funding, digital infrastructure, interdisciplinary collaboration, and institutional incentives. This observation is consistent with Bauer et al. (2020), who argued that sustainability governance must be complemented by institutional resources and innovation systems to achieve meaningful transformation in higher education.

Overall, these findings suggest that sustainable research practices within Nigerian higher education institutions require more than environmental awareness or institutional commitment. Universities should strengthen research ethics training, invest in digital research infrastructure, promote interdisciplinary collaboration, and develop innovation ecosystems that support environmentally responsible, socially responsive, and economically sustainable research practices.

The mediation analysis revealed that innovative capacity significantly mediated the relationship between environmental consciousness and the three dimensions of sustainable research practices, although the magnitude of the indirect effects was relatively small. This finding suggests that environmental consciousness alone is insufficient to produce sustainable research outcomes unless researchers possess the ability to transform environmental awareness into innovative research practices. The significant mediation indicates that innovation serves as an important mechanism through which environmentally conscious researchers adopt environmentally responsible, economically efficient, and socially responsive research practices. This finding supports the argument of John Elkington (1997), which emphasizes that sustainability requires the integration of environmental, economic, and social considerations through strategic actions rather than awareness alone. Similarly, the finding aligns with Schaap et al. (2025), who reported that innovative capacity enables higher education institutions to convert sustainability aspirations into practical institutional outcomes. Bell (2010) and Blumenfeld et al. (1991) likewise demonstrated that innovation and problem-solving facilitate the application of knowledge to real-world challenges, thereby improving sustainable outcomes. Nevertheless, the standardized indirect effects ($\beta = .004-.014$) were relatively small, indicating that although innovation significantly mediates these relationships, its practical contribution remains modest. This suggests that innovation should complement, rather than replace, institutional investments in sustainability policies, digital research infrastructure, and environmental support systems.

The findings further demonstrated that innovative capacity significantly mediated the relationship between knowledge of ethical guidelines and environmental, economic, and social sustainable research practices. These results imply that ethical knowledge contributes more effectively to sustainable research when researchers possess the creativity and problem-solving

skills necessary to translate ethical principles into innovative research practices. Ethical guidelines establish the standards for responsible research conduct, but innovation provides the practical means through which these standards are implemented efficiently and sustainably. This finding is consistent with Lozano et al. (2015), who argued that sustainability in higher education depends on integrating ethical governance with innovation and institutional commitment. Similarly, Leal Filho et al. (2019) emphasized that universities achieve sustainable development more effectively when ethical principles are embedded within innovative teaching and research systems. The finding also agrees with Bauer et al. (2020), who observed that institutional transformation towards sustainability requires innovation alongside governance structures. However, although statistically significant, the mediation effects were relatively weak, suggesting that ethical knowledge alone cannot substantially improve sustainable research practices without complementary institutional resources, digital technologies, and supportive research environments. Consequently, universities should integrate ethics education with innovation training, digital research tools, and interdisciplinary collaboration to strengthen sustainable research outcomes.

Conversely, innovative capacity did not significantly mediate the relationship between institutional culture and environmental, economic, or social sustainable research practices. This finding indicates that institutional culture exerts its influence on sustainable research practices directly rather than through researchers' innovative capacity. A possible explanation is that institutional values, policies, leadership commitment, and governance structures provide sufficient guidance for researchers to adopt sustainable practices without innovation functioning as an intermediary mechanism. This finding is supported by Wright (2010), who reported that institutional leadership and organizational commitment play central roles in embedding sustainability within universities. Similarly, Lozano (2011) found that sustainability reporting and institutional policies directly shape sustainable practices across higher education institutions. Bauer et al. (2020) likewise concluded that sustainability governance depends primarily on organizational commitment and institutional structures rather than individual innovation alone. The absence of significant mediation may also reflect the realities of Nigerian higher education, where innovation is frequently constrained by inadequate funding, limited digital infrastructure, and insufficient institutional incentives despite supportive organizational cultures. Consequently, institutional commitment to sustainability may produce sustainable research behaviours directly through policies and regulations rather than through enhanced innovative capacity.

7. Limitations

The limitations of this study primarily stem from its scope, sample size, and methodological approach. First, the scope is confined to a specific group of institutions or research environments, which may not reflect the full range of practices and conditions across all research institutions. Consequently, the findings may not be applicable to all academic or research settings, especially in regions with distinct socio-economic, cultural, or institutional factors.

Second, the study's sample size and composition limit the generalizability and reliability of the results. Since the sample only involved academic staff, it does not fully represent the broader population of researchers, potentially introducing bias. The lack of diversity in the sample could also influence the external validity, as different groups might show varying levels of environmental awareness, knowledge of ethical guidelines, and innovative capacity. Additionally, the reliance on self-reporting may have led to socially desirable responses or inaccuracies in participants' self-assessment of their environmental consciousness, ethical knowledge, or innovative capacity, leading to potential biases. Moreover, the study's use of cross-sectional data restricts the ability to observe changes or dynamics over time, providing only a snapshot of relationships at a single point. To address these limitations, future research should aim to increase the sample size and diversity across different institutions, regions, and disciplines to improve generalizability. Furthermore, qualitative methods, such as interviews, could offer deeper insights into the mechanisms driving sustainable research practices.

8. Conclusion

This study provides valuable insights into the connections between environmental consciousness, knowledge of ethical guidelines, institutional culture, innovative capacity, and sustainable research practices in the environmental, economic, and social domains. The findings suggest that environmental consciousness is linked to both economic and social sustainable research practices and to innovative capacity, but does not show a direct link with environmentally sustainable research practices. Knowledge of ethical guidelines, institutional culture, and innovative capacity are found to be critical in shaping sustainable research practices across all three domains. Specifically, knowledge of ethical guidelines has direct relevance to environmental, social, and economic sustainability, and institutional culture shows a similar direct effect. The study also reveals that innovative capacity mediates the relationship between environmental consciousness and sustainable research practices, as well as between knowledge of ethical guidelines and sustainable research practices, indicating the pivotal role of innovation in driving sustainability initiatives. However, innovative capacity does not mediate the relationship between institutional culture and sustainable research practices, suggesting that cultural factors alone may be sufficient to influence sustainability outcomes.

9. Theoretical and Practical Implications

This study contributes to existing theories on sustainable research practices by illustrating the complex interaction between institutional and individual factors. The mediation of innovative capacity between environmental consciousness and sustainable research practices offers a novel perspective on how innovation facilitates translating awareness into practical outcomes. Likewise, the direct connection between knowledge of ethical guidelines, institutional culture, and sustainability practices reinforces the theoretical notion that cultural and ethical frameworks are essential in shaping research behavior. The results highlight the need for a comprehensive approach to sustainability, where both individual awareness and institutional context are key drivers.

For research institutions and policymakers, the study emphasizes the importance of fostering an institutional culture that supports sustainability and ethical guidelines. Promoting environmental consciousness alongside innovative capacity can improve sustainable research outcomes, particularly in the economic and social domains. Institutions should focus on educating researchers about ethical guidelines and creating environments that encourage innovative solutions to sustainability challenges. The lack of mediation by innovative capacity in the relationship between institutional culture and sustainability suggests that cultivating a strong culture of sustainability within an institution can effectively drive responsible and sustainable research practices. Additionally, the findings imply that institutions must ensure that researchers not only grasp ethical principles but also possess the tools and capacity to innovate in applying them effectively.

10. Recommendations

Institutions should cultivate a culture that inherently supports sustainability across all research domains. This can be achieved through leadership that prioritizes sustainability, collaborative practices, and ethical research standards. Universities and research organizations should prioritize training on ethical guidelines and sustainability practices, ensuring that researchers understand the importance of ethics in their work and its direct impact on sustainability. Institutions should create an environment that nurtures innovative thinking. This includes providing resources, collaboration opportunities, and training to foster creative problem-solving in research. Sustainability should be embedded in institutional research policies, with clear guidelines and incentives for conducting research that addresses environmental, social, and economic issues. To achieve more impactful sustainable research, institutions should promote collaboration between disciplines to bring diverse perspectives and innovative solutions to sustainability challenges.

Acknowledgements: The researchers are grateful to all the respondents who participated in the study without been coerced to do so. The research assistants and the entire team members that sacrificed their time for this study are also deeply appreciated. The content validators who are all professors are acknowledge for their time in this work.

Author contributions: All authors substantially and equally contributed to the work described, including conception, study design, execution, data acquisition, analysis, and interpretation, or a combination of these aspects.

Data availability statement: The data that support the findings of this study are not publicly available due to confidentiality agreements and ethical considerations involving participant privacy. However, anonymized data may be made available from the corresponding author upon reasonable request and with appropriate institutional approvals.

Declaration of generative AI: Generative artificial intelligence (AI) tools were used solely to assist with language editing and improving the clarity and readability of the manuscript. The authors carefully reviewed, verified, and edited all AI-assisted content and accept full responsibility for the accuracy, integrity, and originality of the final manuscript.

Declaration of interest: The authors declare no competing financial or personal interests in this paper.

Ethical approval and consent: The study protocol was reviewed and approved by the institutional review board of Alex Ekwueme Federal University (IRB/FUNAI/0132/0809). Participants were informed about the purpose of the study, how the data would be used, and reassured that their information would be protected through encryption, accessible only to the lead researcher.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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