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Integrating Artificial Intelligence for Sustainable Development: A Fuzzy Decision-Making Approach

Mouhamed Bayane Bouraima[1,2,*]

[1] Organization of African Academic Doctors (OAAD), Off Kamiti Road, P.O Box 25305-00100, Nairobi, Kenya
[2] International School of Technical Education, Sichuan University of Architectural Technology, Deyang, 618000, Sichuan, China

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ABSTRACT

Artificial Intelligence (AI) is reshaping various sectors and offers powerful potential to support sustainable development goals (SDGs) across Africa. Nevertheless, its full adoption remains restricted by context-specific challenges within the region, which hinder its large-scale implementation. This study applies a fuzzy simple weight calculation (F-SIWEC) method to systematically assess strategies for optimizing AI for sustainable development (SD) in Africa. Data were collected from four domain experts who evaluated six strategies, and the adopted method was then applied to determine the relative importance of each strategy. The results reveal that infrastructure and connectivity, human capital and AI literacy, and regulatory frameworks and ethical guidelines constitute the three most important strategies to optimize AI for SD on the continent. The study makes a meaningful contribution to the decision sciences and management literature by offering practical insights for legal experts, technologists, representatives from civil society, and policymakers, and concludes by outlining clear avenues for future research.

1. Introduction

Artificial intelligence (AI) has emerged from a unique technological concept into a powerful and adaptable tool capable of overcoming highly complicated and multidimensional challenges across distinct domains [1]. Its adoption in sustainable development is optimistic, as it can provide transformative progress in key areas such as environmental protection, social inclusion, and economic development [2]. Recently, policy and scholarly interest has increased around the adoption of AI to address critical development challenges in Africa, where continuous issues comprising climate vulnerability, poverty, and restricted access to important services remain especially acute [3].

AI may be largely defined as a computer science branch related to the design of systems capable of discerning their environment and absolutely selecting actions that optimize goal achievement [4].

* *Corresponding author.*
E-mail address: *mouba121286@yahoo.fr*

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This branch seeks to reproduce main aspects of human cognition, including language comprehension, sensory perception, logical reasoning, problem solving, and learning [5]. In reality, AI systems depend on advanced algorithms and dynamic modeling approaches to assist decision-making, examine data, and repeatedly enhance performance based on feedback, often reaching levels of accuracy and speed that surpass the abilities of human beings in particular implementations [6]. Important AI applications include computer vision technologies, speech-based systems, and natural language processing [7]. In contrast, sustainable development is frequently recognized as a guiding framework that looks for the progress of human well-being while keeping the long-term ability of natural systems to offer important ecosystem services and resources that sustain socio-economic activities [8].

While AI has significant potential to support sustainable development in Africa, its successful implementation remains limited by various context-specific challenges that are inadequately handled in previous studies. Based on the current complicated socio-economic and environmental conditions in Africa, AI has appeared as an important tool for promoting progress towards the United Nations Sustainable Development Goals (UN-SDGs), which focus on important concerns at the international level such as social justice, environmental degradation, climate change, inequality, and poverty [9]. Practically, AI-enabled solutions have shown promise across main sectors; for example, AI-based agricultural systems can improve climate resilience by predicting weather patterns and optimizing farming decisions [10], while AI diagnostic tools in healthcare can ameliorate service quality and coverage in underdeveloped areas through automated medical image analysis [11]. However, the sustainability and contextual stability of these applications in the African context remain underexamined, emphasizing the necessity for systematic and context-aware analytical frameworks.

Previous studies often generalize perceptions from other regions, thereby underrepresenting Africa's distinct circumstances. Although Mienye *et al.,* [12] explore the role of AI in supporting sustainable development in Africa and propose strategic frameworks, their study does not prioritize these strategies according to their significance, nor does they adopt a powerful managerial decision-making tool for such assessment. Given the proven effectiveness of multi-criteria decision-making (MCDM) methods in addressing strategic problems [13, 14], the motivation of this study is to advance the literature in decision science through the identification and prioritization of AI-driven strategies for sustainable development in Africa.

In this circumstance, the main research questions (RQs) and research objectives (ROs) are raised.

RQ-1: What are the main AI-driven strategies for sustainable development in Africa?

RO-1: To examine the most important AI-driven strategies for sustainable development in Africa.

RQ-2: Which methodological approach to implement for assessing the the most important AI-driven strategies for sustainable development in Africa?

RO-2: To adopt a fuzzy SImple WEight Calculation (F-SIWEC) for assessing these AI strategies.

RQ-3: What implications do these appropriate strategies offer for sustainable development in Africa?

RO-3: To offer lessons to assist legal experts, technologists, representatives from civil society, and policymakers in using appropriate AI strategies for sustainable development in Africa.

The contribution of this study is as follows. Unlike earlier AI research for sustainable development in Africa that depends on either qualitative or review approaches, this study for the time applied a fuzzy SIWEC approach to determine the most important AI strategies for sustainable development in the continent.

The remaining of the study is as follows: Section 2 is the literature review, problem definition is presented in Section 3, Section 4 provides the methodology, the application is implemented in Section 5, Section 6 provides the sensitivity analysis, the findings and discussion are made in section

7, the managerial implications are shown in Section 8, and conclusions and recommendations are in the final section.

2. Methodology

Two sub-sections have been shown as follows.

2.1 Artificial intelligence-related studies

AI has been used in various domains. In the education sector, Alwaqdani [15] explored the teachers' views toward its integration as an instrument for their educational practices. Their results indicate how its adoption has the ability to save time, personalize learning experiences, and support the development of enriching activities. In the agriculture sector, Pallottino *et al.,* [16] describe the crucial significance of various tasks for this sector, including precision and animal farming, produced by the increase of new technologies. In healthcare, Olawade *et al.,* [17] explained the AI-driven technologies, while addressing the ethical issues and restrictions associated with AI deployment. In the transportation sector, Jadhav *et al.,* [18] demonstrate how AI can direct us towards a more sustainable and effective way to move globally, visualizing a future where seamless and green transportation is within our environment. Ambadekar *et al.,* [19] present a structured assessment that employs vision systems encouraging researchers to examine their potential integration with machine learning from an Industry 4.0 outlook. Zhao and Chen [20] explore the relation between AI adoption and the ability of green management. Tuo *et al.,* [21] developed an extensive research approach that examines the systematic relationship between AI and different aspects of tourism. Malhotra and Kharub [22] evaluated the impact of last-mile logistics on supply chain consistency, with special emphasis on performance as well as cooperation and coordination among logistics enterprises. Hao and Demir [23] pinpoint and examine the main enablers and barriers affecting AI in various stages of supply chain management. Dobrodolac *et al.,* [24] explore the potential implementation and effects of AI with postal systems. Table 1 indicates the AI related studies.

Table 1
AI related studies

Authors	Objective	Methodology	Sector
Alwaqdani [15]	Assessing the perceptions of teachers related to AI adoption in education	questionnaire	Education
Pallottino *et al.,* [16]	Implementation and perspectives of generative AI	Review	Agriculture
Olawade *et al.,* [17]	Investigating how AI ameliorate healthcare for disabled peoples.	Quantitative analysis	Healthcare
Jadhav *et al.,* [18]	Assessing the future of AI in transportation	Data science ad sophisticated algorithms	Public transportation system
Ambadekar *et al.,* [19]	AI significance in mechanical engineering	Structured narrative review	Industry 4.0 outlook
Zhao and Chen [20]	Assessing the relation between AI implementation and green management ability	Quantitative empirical methodology	Manufacturing sector
Tuo *et al.,* [21]	AI adoption in tourism	Co-occurrence analysis	Tourism sector
Malhotra and Kharub [22]	Adopting AI to leverage logistics performance in e-commerce	Structured questionnaire	e-commerce
Hao and Demir [23]	Investigating the AI supply chain journey	Empirical interview and systematic literature review	Supply chain management
Dobrodolac *et al.,* [24]	Application AI in parcel delivery systems	Expert survey	Parcel delivery systems

2.2 Implementation of MCDM approaches for AI related studies

MCDM approaches have been adopted in the AI related studies. For instance, Alsalem *et al.,* [25] proposed an integrated approach under q-rung Orthopair fuzzy 2-tuple linguistic framework to evaluate trustworthy AI healthcare implementations. Nawaz et al., [26] identified and prioritized the barriers encountered by disabled older people related to AI adoption in their daily lives under dynamic grey relational environment. Guarini et al., [27] assessed the incorporation of AI in the urban decision-making procedure. Nguyen *et al.,* [28] applied an integrated Pythagorean fuzzy technique to analyze AI technologies in the Vietnamese Telecom Corporation. Aljohani [29] developed an automated decision-making system for the improvement of personalized healthcare recommendations. Yenugula *et al.,* [30] explore the crucial factors for adopting a sustainable AI cloud system in the information technology sector. Aslan and Tolga [31] determine the most suitable areas where AI technology can be employed in aviation MRO activities. Kökçam *et al.,* [32] conducted a bibliometric analysis on AI implementations in predicting the liquefaction of soil. Table 2 presents the studies related to the implementation of MCDM in AI-related studies.

Table 2
MCDM application on AI-related studies

Authors	Objective	Methodology
Alsalem *et al.,* [25]	Exploring reliable AI healthcare implementation	q-ROF2TL-FWZIC-CODAS
Nawaz et al., [26]	Assessing the challenges related to AI adoption	DGRA; TOPSIS
Guarini et al., [27]	Investigation of the cross-functional relationship between AI and actual decision support approach	MCDA
Nguyen *et al.,* [28]	Adoption of AI technologies	PF-AHP-CoCoSo
Aljohani [29]	AI-driven approach for ameliorating elderly people treatment	Fuzzy VIKOR
Yenugula *et al.,* [30]	Assessing influential parameters for adopting durable AI cloud system	AHP-ISM-MICMAC
Aslan and Tolga [31]	AI adoption in aviation maintenance	VIKOR, TODIM
Kökçam *et al.,* [32]	Forecasting soil liquefaction	MCDM

Note: AHP-Analytical Hierarchy Process; CoCoSo- Combined Compromise Solution; CODAS-Combinative Distance-Based Assessment; DGRA- Dynamic Grey Relational Analysis; FWZIC-Fuzzy-Weighted Zero-Inconsistency; ISM- Interpretive Structural Modeling; MCDA-Multi-Criteria Decision Analysis; MCDM- Multi-Criteria Decision Making; MICMAC- Cross-Impact Matrix Multiplication Applied to Classification; PF- Pythagorean Fuzzy; q-ROF2TL-q-Rung Orthopair Fuzzy 2-Tuple Linguistic; TOPSIS-Technique for Order Performance by Similarity to Ideal Solution; TODIM- An Acronym in Portuguese for Interative Multi-criteria Decision Making; VIKOR- VlseKriterijuska Optimizacija I Komoromisno Resenje.

3. Problem definition

Specific strategies must be implemented that represent Africa's different issues and benefits to completely exploit the AI potential for sustainable development. Recurrent challenges, like deficient regulatory frameworks, limited skilled human capital, poor infrastructure, and restricted technological access in rural zones continue to restrict the successful adoption of AI systems. Overcoming these challenges necessitates specific approaches that enhance the scalability, accessibility, and efficiency of AI implementations in development-critical sectors. Therefore, six important strategies are presented for leveraging AI technologies to advance sustainable development, while emphasizing the necessary adaptations to reduce previous structural and institutional barriers. These strategies are developed based on experts' opinions and literature review. Table 3 presents the strategies for optimizing AI for sustainable development.

Table 3
Strategies for AI optimization for sustainable development

Strategies	Description	References
Infrastructure and connectivity (S1)	Enhancing AI performance through internet access expansion, local data centers' deployment, and renewable energy usage.	[33]
Human capital and AI literacy (S2)	Integrate AI education at all levels and raise public awareness for future-ready society construction.	[12]
Innovation and research (S3)	Invest in locally relevant AI while assisting startups and research partnerships	Expert opinion
Regulatory frameworks and ethical guidelines (S4)	Establish ethical AI standards to guarantee responsible and transparent use	[34]
Partnerships and collaborations (S5)	Strengthening AI outcomes through international partnerships and cross-sector collaboration	[35]
Monitoring and evaluation (S6)	Continuously monitor AI impacts and adapt strategies to enhance outcomes	[36]

4. Methodology

In recent years, a novel subjective criteria weighting approach has been proposed by Puška et al., [37]: the SIWEC method, which makes it easier for experts (Es) to determine criteria significance. The assessment of criteria is conducted separately in the absence of comparison and prioritization. Simple procedures and steps are adopted for computing the weights of criteria. Since it has been introduced, various sectors such as the African Continental Free Trade Area initiative potential assessment [38], tourism valorization [39], tourism in cultural heritage [40], railway infrastructure planning [41], transport policy selection [42], sustainable logistics and transport systems [43], electric vehicle selection [44], green digital technology assessment [45], digital twin technology enhancement [46], and renewable energy adoption [47] have adopted it. Figure 1 indicates the flowchart of our methodology.

Fig.1. The flowchart of our methodology

The steps of fuzzy SIWEC are shown as follows.

Step 1. Each criterion associated with importance is evaluated by experts by given linguistic variables (LVs) shown in Table 4 to show the experts ideas.

Step 2. The opinions of experts assessed through LVs are transformed to triangular fuzzy numbers (TFNs) as lower, middle, and upper bounds shown in Eq. (1).

$$\tilde{x}_{ij} = \left(x_{ij}^{l}, x_{ij}^{m}, x_{ij}^{u}\right) \quad (1)$$

Step 3. There is an establishment of an original fuzzy decision matrix based on fuzzy numbers derived from the experts' evaluation. The indicated importance of a specific criterion is represented through each parameter, comprising of uncertainty obtained through the assessment of linguistics.

This matrix shown in Eq. (2) is a base for calculating criteria weight via the SIWEC approach under fuzzy environment.

$$\begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \quad (2)$$

Table 4
Fuzzy linguistic evaluation scale

Linguistic terms	Membership function
Absolutely bad (AB)	(1,1,1)
Very bad (VB)	(1,2,3)
Bad (B)	(2,3,4)
Medium-bad (MB)	(3,4,5)
Equal (E)	(4,56)
Medium-good (MG)	(5,6,7)
Good (G)	(6,7,8)
Extremely good (EG)	(7,8,9)
Absolutely good (AG)	(8,9,10)
Perfect (P)	(9,10,10)

Step 4. Fuzzy values are normalized from decision matrix through their division by the greater upper bound ($\max x_{ij}^{u}$) observed through all criteria and experts in Eq. (3).

$$\tilde{n}_{ij} = \frac{x_{ij}^{l}}{\max x_{ij}^{u}}, \frac{x_{ij}^{m}}{\max x_{ij}^{u}}, \frac{x_{ij}^{u}}{\max x_{ij}^{u}} \quad (3)$$

Step 5. The standard deviation (std.dev_j) are computed based on fuzzy numbers derived from experts. This computation shows consistency or variation in the evaluation of criteria, allowing the approach to emphasize criteria where experts' opinions show greater differentiation, a significant feature of the F-SIWEC technique for apprehending the related significance under uncertainty.

Step 6. The normalized fuzzy rating in Eq. (4) reflected through the multiplication of normalized fuzzy rating by associated values of standard deviation.

$$\tilde{v}_{ij} = \tilde{n}_{ij} \times st.dev_j \quad (4)$$

Step 7. The weighted fuzzy evaluation provided by all experts are summed to provide an aggregation fuzzy weighted values for each parameter. This generates an overall representation of each factor's importance, permitting both individual expert opinions and the uncertainty apprehend in previous steps. The outcomes are a combined fuzzy weight for each factor, which becomes a basis in obtaining the final importance rankings in Eq. (5).

$$\tilde{S}_{ij} = \sum_{j=1}^{n} \tilde{v}_j \quad (5)$$

Step 8. Each separate fuzzy value is divided by the total sum of all fuzzy values to obtain the normalized fuzzy weight for each parameter indicated in Eq. (6). During this process, it is significant to make sure that the lower bound is less or equal to the middle value. This can be done only if there is maintained logical order of fuzzy numbers.

$$\widetilde{w}_{ij} = \frac{S_{ij}^{l}}{\sum_{j=1}^{n} S_{ij}^{u}}, \frac{S_{ij}^{m}}{\sum_{j=1}^{n} S_{ij}^{m}}, \frac{S_{ij}^{u}}{\sum_{j=1}^{n} S_{ij}^{l}} \quad (6)$$

STEP 9. The final fuzzy weights of each criterion are retained through their de-fuzzified or fuzzy form into crisp values, according to the analytical requirements. Herein, de-fuzzified of fuzzy weights are adopted through an appropriate defuzzification technique to transform each fuzzy number inti an individual representative value, shown in Eq. (7).

$$w_{jdef} = \frac{w_{ij}^{l} + 4 \times w_{ij}^{m} + w_{ij}^{l}}{6} \tag{7}$$

5. Application

This study adopted a three-step methodological approach based on the F-SIWEC procedure to establish data-driven prioritization of strategies for optimizing AI for sustainable development. With the objective of producing a systematic guideline for the exploration of this study, six strategies has been found from experts' opinions and the literature review. A panel of four experts comprising of AI practitioners, policymakers, and researchers working towards sustainable development in Africa has been involved. Fuzzy weights are derived from a linguistic decision matrix based on expert evaluations of each criterion, as summarized in Table 5, which presents the initial judgments of the four experts.

Table 5

Linguistic decision-making matrix

	S1	S2	S3	S4	S5	S6
E1	P	AG	G	AG	EG	E
E2	AG	AG	E	EG	G	E
E3	P	EG	MG	EG	G	MB
E4	P	EG	MG	G	G	E

In order to establish an original fuzzy decision matrix based on the opinions of the experts, the data are first normalized to guarantee comparability on a basic scale. Following the F-SIWEC approach, each TFN was divided by the highest upper-bound value across all strategies for each expert, mapping the values into the [0, 1] range. This normalization keeps the proportional relationships among the initial evaluations while removing scale-related bias. The resulting initial and normalized fuzzy decision matrices are presented in Table 6 and represent the basis for obtaining strategies weights in the next stage.

Table 6

Normalized fuzzy decision-making matrix

	S1	S2	S3	S4	S5	S6
E1	(0.9, 1.0,1.0)	(0.8, 0.9,1.0)	(0.6, 0.7,0.8)	(0.8, 0.9,1.0)	(0.7, 0.8,0.9)	(0.4, 0.5,0.6)
E2	(0.8, 0.9,1.0)	(0.8, 0.9,1.0)	(0.4, 0.5,0.6)	(0.7, 0.8,0.9)	(0.6, 0.7,0.8)	(0.4, 0.5,0.6)
E3	(0.9, 1.0,1.0)	(0.7, 0.8,0.9)	(0.5, 0.6,0.7)	(0.7, 0.8,0.9)	(0.6, 0.7,0.8)	(0.3, 0.4,0.5)
E4	(0.9, 1.0,1.0)	(0.7, 0.8,0.9)	(0.5, 0.6,0.7)	(0.6, 0.7,0.8)	(0.6, 0.7,0.8)	(0.4, 0.5,0.6)

After normalization, the F-SEWIC method integrates expert consensus by multiplying each normalized fuzzy value by the corresponding standard deviation, thereby embedding opinion variability into the weighting process. This gives greater importance to strategy where expert views diverge, reflecting their contextual sensitivity. The adjusted values are then summed, as shown in Table 7, to produce the first-level fuzzy weights for each strategy while preserving uncertainty. During these calculations, the triangular fuzzy structure was maintained so that each weight satisfies the condition (lower bound ≤ mode ≤ upper bound).

Table 7
Obtaining final values of the criteria by using fuzzy SIWEC method

Strategies	$\tilde{s}_{ij}$	$\widetilde{w}_{ij}$
S1	(0.65,0.72,0.74)	(0.18,0.22,0.26)
S2	(0.56,0.63,0.71)	(0.15,0.19,0.25)
S3	(0.37,0.44,0.52)	(0.10,0.14,0.18)
S4	(0.52,0.59,0.67)	(0.14,0.18,0.24)
S5	(0.46,0.54,0.61)	(0.13,0.16,0.22)
S6	(0.28,0.35,0.43)	(0.08,0.11,0.15)

The results displayed in Figure 2 for the defuzzified strategies weights suggest a clear ranking regarding the perceived influence of the strategies for optimizing AI for sustainable development from an African perspective.

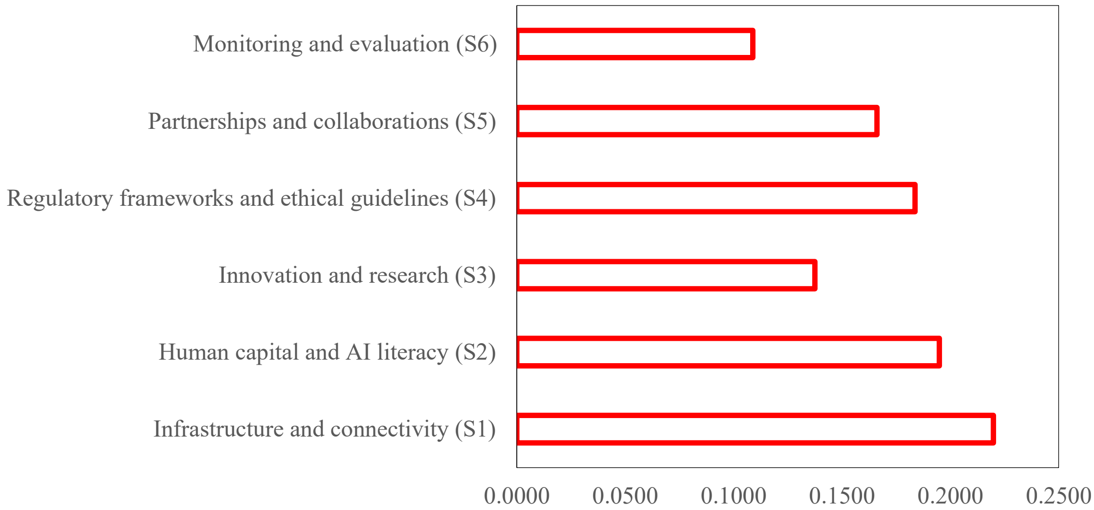

Fig. 2. Defuzzified value of the weights of strategies

6. Findings and Discussion

This study provides insights into the adoption of the fuzzy simple weight calculation technique for thoroughly identifying and prioritizing the AI-driven strategies for sustainable development. Through the implemented technique, infrastructure and connectivity (S1) is the most important AI-driven strategy followed by human capital and AI literacy (S2), and regulatory framework and ethical guidelines (S4).

Various studies confirmed the significant importance of "*infrastructure and connectivity (S1)*" as an AI-driven strategy for sustainable development. Gill *et al.,* [33] indicated how the successful adoption of AI technology greatly depends on the basic feature of powerful infrastructure and extensive connectivity. Deficient connectivity of internet and inadequate electricity supply impede the successful AI technology deployment in many parts of Africa. Therefore, considerable attempts should be made towards the extension of internet access, especially in rural and traditionally disadvantaged zones [48]. To overcome the electricity supply issue, Sarker [49] recommended that renewable energy sources (RES) related investments should be made since these sources offer more adequate power and also are uniform with the SDGs through carbon footprint reduction and reduction of dependence on fossil fuels.

The "*human capital and AI literacy (S2)*" is the second most important AI driven strategy for sustainable development. Southworth *et al.,* [50] indicated how an extensive approach to education and training is necessitated for establishing human capital in AI and data science. They recommended integrating AI into all levels of educational curricula to guarantee that future generations are proficient in the basics of AI and ready for future employment in this area. Similarly, Gerlich [51] recommended raising the overall public's understanding of AI through targeted awareness campaigns, which can illuminate AI technologies by explaining their advantages, addressing ordinary misconceptions, and emphasizing effective case studies where AI has positively affected people.

The third most important strategy is the "*regulatory framework and ethical guidelines (S4)*". Olorunfemi *et al.,* [52] indicated how the establishment of adequate and comprehensive AI regulations and policies is important in harnessing the advantages related to AI adoption while avoiding possible threats. They stated that these policies should monitor how AI systems are created, implemented, and used in society. These policies should overcome a variety of challenges related to inclusivity, accountability, transparency, intellectual property, and data protection. Sallstrom *et al.,* [53] stated that these policies should be formulated by legal experts, technologists, representatives from civil society, and policymakers to guarantee the consideration of diverse perspectives. Besides formal regulations, the adoption of ethical guidelines is important to guarantee AI technologies contribute to the betterment of the public and do not cause harm. Wu [54] indicated that principles related to user privacy respect, transparency, accountability, and fairness should be emphasized in these guidelines.

7. Sensitivity analysis

A sensitivity analysis is conducted to test the results of the study, the evaluations made by the experts, and the validity of the method. Two different sensitivity analysis scenarios were conducted for this study as can been seen in Table 8.

Table 8
Sensitivity analysis

First scenario	S1	S2	S3	S4	S5	S6
Out of 1st Expert	0.225	0.197	0.134	0.182	0.165	0.110
Out of 2nd Expert	0.223	0.189	0.144	0.182	0.167	0.106
Out of 3rd Expert	0.216	0.197	0.136	0.182	0.166	0.114
Out of 4th Expert	0.209	0.201	0.133	0.189	0.167	0.112
Second scenario	S1	S2	S3	S4	S5	S6
Out of 1st strategy	-	0.250	0.176	0.236	0.213	0.139
Out of 2nd strategy	0.273	-	0.171	0.228	0.206	0.135
Out of 3rd strategy	0.255	0.225	-	0.213	0.192	0.126
Out of 4th strategy	0.269	0.238	0.168	-	0.203	0.133
Out of 5th strategy	0.263	0.233	0.164	0.220	-	0.130
Out of 6th strategy	0.247	0.219	0.153	0.205	0.186	-

In the first scenario, each expert evaluation was excluded from analysis, and the changes in the results were examined. In the ranking obtained from the first scenario, strategy S1 was identified as the criterion with the highest importance level. In the second scenario, each criterion was removed from the decision problem individually, and the changes in the results were examined. In this scenario, strategy S1 was again identified as the criterion with the highest level of importance. In the scenario where only strategy S1 was removed, strategy S2 was identified as the criterion with the highest importance level. This criterion was calculated as the second most important criterion in the study and in the other sensitivity analysis scenarios. As a result of the sensitivity analyses, no changes were observed in the criterion weighting rankings. This clearly demonstrates that the study, the evaluations made by the experts, and the method are robust.

8. Managerial Implications

As managerial implications, the AI-driven sustainable development should be approached by the managers via a structured strategy that concurrently builds up governance, human capital, and infrastructure. This signifies investing in adequate digital connectivity and RE to assist AI deployment, establishing a workforce through public awareness, training, and education measures to construct AI literacy, and enacting powerful ethical and regulatory schemes that guarantee data protection, accountability, and transparency. By lining up these three pillars, risks can be reduced, responsible AI adoption can be accelerated, and durable and inclusive outcomes will be attained. Managers should also encourage collaboration between government institutions, private sector actors, and academic organizations to facilitate knowledge exchange and strengthen the implementation of AI-driven initiatives. Furthermore, allocating dedicated financial resources and incentives can support the adoption of innovative AI technologies across different sectors.

9. Conclusions and Future Recommendations

In this study, a fuzzy SIWEC methodology is used to evaluate the strategies for optimizing AI for sustainable development (SD) in Africa. For that, six strategies are identified based on experts' opinions and literature review. To collect the data, four experts were involved. The results indicated that infrastructure and connectivity, human capital and AI literacy, and regulatory framework and ethical guidelines constitute the three most important strategies to optimize AI for SD in the continent. While the study has made some contributions, it has some limitations. First, a small number of experts participated. Second, since Africa is comprised of 54 countries, the findings cannot be generalized because every country may have specific characteristics. Third, the study relies primarily on expert judgment and qualitative assessments, which may introduce a degree of subjectivity into the evaluation process. Fourth, the analysis focuses mainly on strategic-level factors and does not incorporate quantitative performance data from specific AI projects or national case studies. Future studies should consider increasing the number of experts, conducting the study at national or regional levels, incorporating larger expert panels and empirical datasets to enhance robustness, and integrating real-world project data or country-level indicators to validate and extend the findings. In addition, new methodology can be adopted using an integration of data envelopment analysis (DEA) and fuzzy logic [55]. Moreover, we should consider the clustering approach as a future research direction given the number of African countries with various characteristics. In addition, the methodology proposed in this paper can be further extended using frameworks such as Neutrosophic sets, Pythagorean fuzzy sets, spherical fuzzy sets, and circular Complex Picture Fuzzy Sets [56].

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Conflict of Interest

There is no conflict of interest to disclose.

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