



Data-Driven SWOT Analysis of Artificial Intelligence Adoption for Achieving Gender Equality (SDG5): An Interval-Valued Spherical Fuzzy Methodology

Samirath Bakary¹, Mouhamed Bayane Bouraima^{2*}, Qiu Yanjun³

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
³ School of Civil Engineering, Tarim Institute of Technology, No. 4040 SanWujiu Street, Alaer, Xinjiang, 843399, China

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ABSTRACT

This study adopted an interval-valued spherical fuzzy-based strategic approach to assess the strengths, weaknesses, opportunities, and threats (SWOT) related to the role of artificial intelligence (AI) in gender equality under Sustainable Development Goal 5 (SDG 5). First, 13 SWOT factors were identified based on a literature review. Then, data were collected from four domain experts, and interval-valued spherical fuzzy stepwise weight assessment ratio analysis (IVSF-SWARA) was applied to determine the weights of the SWOT factors. The findings reveal that AI reduces gender bias in recruitment (S2) and AI detects harassment and supports legal protection (O2) serve as key enablers of gender equality. In contrast, biased AI reinforces gender inequalities (W3) and patriarchal norms hinder women's empowerment (T1) constitute major barriers to achieving this goal. The study makes a meaningful contribution to the decision sciences and management literature by offering practical insights for policymakers seeking to achieve gender equality and concludes by outlining clear avenues for future research.

1. Introduction

Gender inequality represents a main concern that restrict the economic growth, social inclusion, and sustainable advancement [1]. Although there is a considerable effort at international level, there is disparities among women and girls related to education accessibility, digital resources, healthcare, and decision-making advantages [2]. To overcome these challenges, the United Nations (UN) established Sustainable Development Goal 5 (SDG5): Achieve Gender Equality and Empower All Women and Girls as a core component of the 2030 Sustainable Development Agenda [3, 4]. SDG5 eradicate discrimination, diminish structural challenges, and promote equal involvement of women in socio- economic, and political activities. In this situation, emerging technologies, particularly artificial intelligence (AI), are increasingly recognized as potential drivers for accelerating gender equality [5]. Through its ability to analyze large-scale data, identify patterns, and support intelligent

* Corresponding author.

E-mail address: mouba121286@yahoo.fr

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decision-making, AI can contribute to SDG5 by improving gender-responsive policies, expanding access to education and healthcare, supporting fair recruitment processes, and detecting discriminatory practices [6].

Nevertheless, the connection between AI adoption and gender equality is complicated and comprises both considerable advantages and potentials threats [7]. While AI can promote gender equality through various new solutions, restricted representation of women in AI development, and ethical issues may reduce its success. Therefore, AI should be seen not only as socio-technical system affected by cultural, institutional, and governance parameters, it is also technological innovation. Previous research have mainly assessed definite AI adoptions in gender issues [8], whereas restricted attention has been made to an extensive assessment of strategic influential parameters of AI adoption to reach SDG5. Furthermore, antecedent study has frequently shown how beneficial AI technology is while inadequately addressing its restriction and external issues, producing a necessity for a more stable evaluation framework [9, 10].

To address these limitations, this study employs a strength–weakness–opportunity–threat (SWOT) analysis framework to extensively assess the role of AI adoption in promoting SDG5. As a strategic decision-support approach, SWOT analysis permits the assessment of both internal and external parameters affecting the AI adoption [11]. Through the incorporation of these four aspects, this approach offered a panoramic apprehension of how AI potential can be used while eradicating barriers related to social, ethical, and technological challenges. The motivation of this research stems from the risen demand for responsible and inclusive AI strategies that align technological innovation with SDGs. Assessing main influential parameters to AI adoption can support policymakers, organizations, and technology developers in the implementation of successful measures that foster fairness, accessibility, and women’s empowerment.

This study contributes to the existing literature in three main ways. First, a comprehensive framework for assessing AI adoption as a strategic mechanism for achieving SDG5: Gender Equality is established, moving beyond isolated AI applications toward a broader sustainability perspective. Second, it bridges the fields of AI, sustainable development, and gender studies by examining both the enabling conditions and constraints associated with AI implementation. Third, it provides practical insights by identifying key strategic factors that can support decision-makers in promoting responsible AI adoption while minimizing potential risks.

The remainder of this paper is as follows: Section 2 reviews the literature; Section 3 presents the research methodology; Section 4 discusses the application and results; Section 5 presents the comparative analysis, Section 6 provides the findings and discussion, and Section 7 concludes the study with key findings, limitations, and future research directions.

2. Literature

Recent studies have highlighted the dual role of AI in promoting and challenging SDG5. For instance, Mohammadi *et al.* [12] found that Google Vision AI can reproduce gender and racial stereotypes in professional representations, particularly by associating scientific roles with men and dominant groups. Fulgu and Capraro [13] demonstrated that GPT-based models may contain implicit gender biases, while Hou *et al.* [14] showed that AI explainability can improve users’ ability to recognize biased behaviors and influence trust perceptions. Isaksson [15] emphasized that gender bias in healthcare AI originates from unequal datasets and social structures, requiring both technical and institutional solutions. Lütz [16] highlighted the need for stronger gender-sensitive governance mechanisms within AI regulations, whereas Locke and Hodgdon [17] revealed that visual generative AI often reinforces traditional gender stereotypes in occupational and social representations. Stecker *et al.* [18] further argued that AI can support SDG 5 through improved access, inclusion, and

empowerment, but may also intensify inequalities without ethical governance and inclusive development. Despite these contributions, existing studies mainly focus on identifying AI-related gender biases and regulatory challenges, while limited research has systematically evaluated the broader factors influencing AI adoption for achieving SDG5 under SWOT analysis. Table 1 presents the studies related to AI adoption in achieving or not SDG5.

Table 1
Studies related to AI adoption in achieving or not SDG5

Authors	Methodology	Objective	Findings
Mohammadi <i>et al.</i> [12]	AI image evaluation	Identify gender and racial bias in AI vision systems	AI reinforces stereotypes in scientific representation
Fulgu and Capraro [13]	GPT response experiments	Detect gender bias in generative AI	GPT reproduces implicit gender stereotypes
Hou <i>et al.</i> [14]	User-based experiment	Examine AI bias perception and trust	Explainability improves bias detection and trust evaluation
Isaksson [15]	Critical literature review	Explore gender bias mitigation in healthcare AI	Bias arises from unequal data and requires multi-level solutions
Lütz [16]	Legal and policy analysis	Assess AI regulation for gender equality	Stronger gender-sensitive AI governance is needed
Locke and Hodgdon [17]	Generative AI output analysis	Examine gender bias in AI-generated images	AI images often reproduce traditional gender roles
Stecker <i>et al.</i> [18]	Interdisciplinary review	Evaluate AI's role in SDG 5	AI enables equality but may reinforce disparities without governance

3. Methodology

In this section, data collection is conducted through literature review and 13 SWOT factors related to AI adoption to achieve SDG5 are assessed using the IVSF-SWARA approach. This approach comprises of nine steps as follows [19, 20].

Step 1. The problem is defined through the 13 factors under SWOT analysis.

Step 2. Experts used IVSF linguistic scales in Table 2 to prioritize factors in decreasing order under each category.

Table 2
Linguistic terms [21, 22]

Linguistic terms	IVSF number	Score index
Absolutely more important (AMI)	([0.85, 0.95], [0.10, 0.15], [0.05, 0.15])	9,00
Very high important (VHI)	([0.75, 0.85], [0.15, 0.20], [0.15, 0.20])	7,00
High important (HI)	([0.65, 0.75], [0.20, 0.25], [0.20, 0.25])	5,00
Slightly more important (SMI)	([0.55, 0.65], [0.25, 0.30], [0.25, 0.30])	3,00
Equally important (EI)	([0.50, 0.55], [0.45, 0.55], [0.30, 0.40])	1,00
Slightly low important (SLI)	([0.25, 0.30], [0.55, 0.65], [0.25, 0.30])	0,33
Low important (LI)	([0.20, 0.25], [0.65, 0.75], [0.20, 0.25])	0,20
Very low important (VLI)	([0.15, 0.20], [0.75, 0.85], [0.15, 0.20])	0,14
Absolutely low important (ALI)	([0.10, 0.15], [0.85, 0.95], [0.05, 0.15])	0,11

In Eq. (1), the weight matrix is established as follows.

$$\tilde{W} = \begin{bmatrix} \tilde{\mu}_{11} & \tilde{\mu}_{12} & \cdots & \tilde{\mu}_{1t} \\ \tilde{\mu}_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \vdots \\ \tilde{\mu}_{n1} & \cdots & \cdots & \tilde{\mu}_{nt} \end{bmatrix} \quad (1)$$

where n –criteria numbers, t -experts ($p=1, 2, \dots, t$).

Step 3. After important scores are attributed by experts, they are aggregated through the arithmetic mean, and IVSWAM is adopted for weighting the weights of experts.

Step 4. In Eq. (2), positive score values are computed in the aggregated matrix $\tilde{A}$ for IVSF weights.

$$s_j = \text{Score}(\tilde{\beta}_j) + 1 \quad (2)$$

Step 5. There is organization of criteria based on their significance scores.

Step 6. There is determination of each criterion (c_j) significance through the analysis of the scores s_j .

Step 7. In this step, k_j is computed through Eq. (3).

$$k_j = \begin{cases} 1 & j = 1 \\ c_j + 1 & j > 1 \end{cases} \quad (3)$$

Step 8. In this step, the unscaled weights q_j are determined through Eq. (4).

$$q_j = \begin{cases} 1 & j = 1 \\ \frac{x_{j-1}}{k_j} & j > 1 \end{cases} \quad (4)$$

Step 9. In this step, the normalization of criteria weights are used to determine the corresponding weights through Eq. (5).

$$w_j = \frac{q_j}{\sum_{j=1}^n q_k} \quad (5)$$

4. Application

The IVSF-SWARA method is applied to evaluate and rank the SWOT factors of AI adoption to achieve SDG5. To ensure a reliable assessment, we conducted interviews with four experts selected based on their background indicated in Table 3. Using Table 2, the experts provided their evaluations, which were subsequently used to assess the SWOT factors in Table 4 [23]. The identification and selection of the 13 SWOT factors followed a systematic procedure. First, an extensive literature review was conducted to identify the key factors associated with AI adoption, gender equality, and SDG5 achievement. Relevant factors were extracted from previous studies, international reports, and policy documents focusing on digital transformation, women's empowerment, and the social impacts of AI. Second, the preliminary factors were screened based on their relevance, frequency of occurrence, and alignment with the research objective of evaluating AI adoption for SDG5. Third, the refined factors were categorized into four SWOT dimensions (Strengths, Weaknesses, Opportunities, and Threats) according to whether they represented internal advantages, internal limitations, external development opportunities, or external challenges. Finally, the selected factors were validated by the four experts to ensure their relevance, comprehensiveness, and applicability to the research context.

Table 3

Participant's backgrounds

Experts	Gender	Profession	Sector/Role	Experience (Years)
E-1	Male	Gender and social policy specialist	National policy planning unit (gender equality and social inclusion division)	5-10 years
E-2	Female	Educational researcher (gender studies & AI in education)	University/academic research institute	5-10 years

Table 3

Continued

Experts	Gender	Profession	Sector/Role	Experience (Years)
E-3	Male	AI and digital transformation specialist	International development organization (AI for social inclusion programs)	5-10 years
E-4	Female	School administrator (inclusive education coordinator)	Public secondary school/education management unit	.years

Table 4

SWOT analysis related to AI adoption for SDG5 achievement [23]

Strengths (S)	Weaknesses (W)
Mobile internet expands women's empowerment (S1)	AI bullying detection raises privacy concerns (W1)
AI reduces gender bias in recruitment (S2)	Low digital literacy increases women's dependency (W2)
Blockchain and mobile banking empower women economically (S3)	Biased AI reinforces gender inequalities (W3)
Opportunities (O)	Social media reduces privacy (W4)
Social media promotes women's awareness and collaboration (O1)	Threats (T)
AI detects harassment and supports legal protection (O2)	Patriarchal norms hinder women's empowerment (T1)
	Government retaliation suppresses women's rights (T2)
	Digital harassment on social media increases (T3)
	Limited digital skills reduce women's employment opportunities (T4)

4.1 Prioritizing of SWOT factors

Step 10. Assessment of strengths factors affecting the AI adoption to achieve SDG5.

Step 11. Determination of their weights by four experts based on assessment of factors from Table 5.

Table 5

Strengths factors assessment

Strengths	E-1	E-2	E-3	E-4
S1	VHI	HI	HI	HI
S2	AMI	VHI	AMI	VHI
S3	HI	SMI	EI	EI

Note: E: Expert.

Step 12. At initial, there is use of mathematical expressions to change the linguistic variables (LV) from Table 2. Next, the opinions of experts are aggregated in Table 6, assuming equal weights for all experts.

Table 6

Aggregated evaluations of strengths factors

Criteria	a	b	c	d	e	f
S1	0.6791	0.7807	0.1861	0.2364	0.0349	0.0559
S2	0.8072	0.9141	0.1225	0.1732	0.0106	0.0310
S3	0.5568	0.6387	0.3172	0.3881	0.0690	0.1127

Step 13. Provision of the computation of results for criteria in Table 7.

Table 7

Positive scores of criteria

	S2	S1	S3
s_j	1.7209	1.4896	1.2312

Step 14. The rank of factors under strength category is $S2 > S1 > S3$.

Step 15. The comparative importance of strength factors are calculated in Table 8.

Table 8

Comparative significances of criteria

	S2	S1	S3
c_j	-	0.231	0.258

Step 16. The coefficients of the strength factors are calculated in Table 9.

Table 9

Coefficients for criteria

	S2	S1	S3
k_j	1	1.231	1.258

Step 17. The disorganized criteria weights are shown in Table 10.

Table 10

Disorganized criteria weights

	S2	S1	S3
q_j	1	0.812	0.645

Step 18. Table 11 indicated the final weights of strength factors.

Table 11

Final weights of strength factors

	S2	S1	S3
q_j	0.406	0.331	0.263

In Table 11, it was revealed that AI reduces gender bias in recruitment (S2, 0.406) is the most important strength factor related to AI adoption to achieve SDG5 followed mobile internet expands women's empowerment (S1, 0.331). The least important strength factor to achieve SDG 5 remains blockchain and mobile banking empower women economically (S3, 0.263).

Same procedure calculation is conducted under weakness, opportunity, and threat categories. Under the weaknesses category, biased AI reinforces gender inequalities (W3, 0.338) is identified as the primary weakness, as indicated in Table 12. Low digital literacy increases women's dependency (W2, 0.276) is the second most critical weaknesses followed by social media reducing privacy (W4, 0.228). AI bullying detection raises privacy concerns (W1, 0.157) is the least critical weakness.

Table 12

Final weights of weakness factors

	W3	W2	W4	W1
q_j	0.338	0.276	0.228	0.157

Regarding opportunities, AI detects harassment and supports legal protection (O2, 0.566) is the most important opportunity (Table 13). Meanwhile, social media promotes women's awareness and collaboration (O1, 0.434) is the least important opportunity.

Table 13
Final weights of opportunity factors

	O2	O1
q_j	0.566	0.434

In Table 14, patriarchal norms hinder women's empowerment (T1, 0.506) is the most critical threat followed by limited digital skills reducing women's employment opportunities (T4, 0.222). Government retaliation suppresses women's rights (T2, 0.118) is the least critical threat.

Table 14
Final weights of threat factors

	T1	T4	T3	T2
q_j	0.506	0.222	0.154	0.118

5. Comparative analysis

To validate the proposed approach, a comparative analysis is conducted between IVSF-SWARA and IVSF-AHP. The IVSF-AHP method separately indicated the relative significance of the SWOT sub-criteria. As shown in shown in Figure 1 bellows, same results are obtained from both approaches, with only little variations. This indicates how powerful and consistent our proposed framework is, validating our findings. The high agreement between the two methods confirms the robustness of the proposed framework in identifying the priority SWOT factors under uncertain conditions. Although IVSF-SWARA and IVSF-AHP employ different weighting mechanisms, the obtained rankings remain consistent, indicating the stability of the results. The slight variations can be attributed to the differences in their calculation procedures, as IVSF-SWARA is based on sequential comparative evaluations, whereas IVSF-AHP relies on pairwise comparisons.

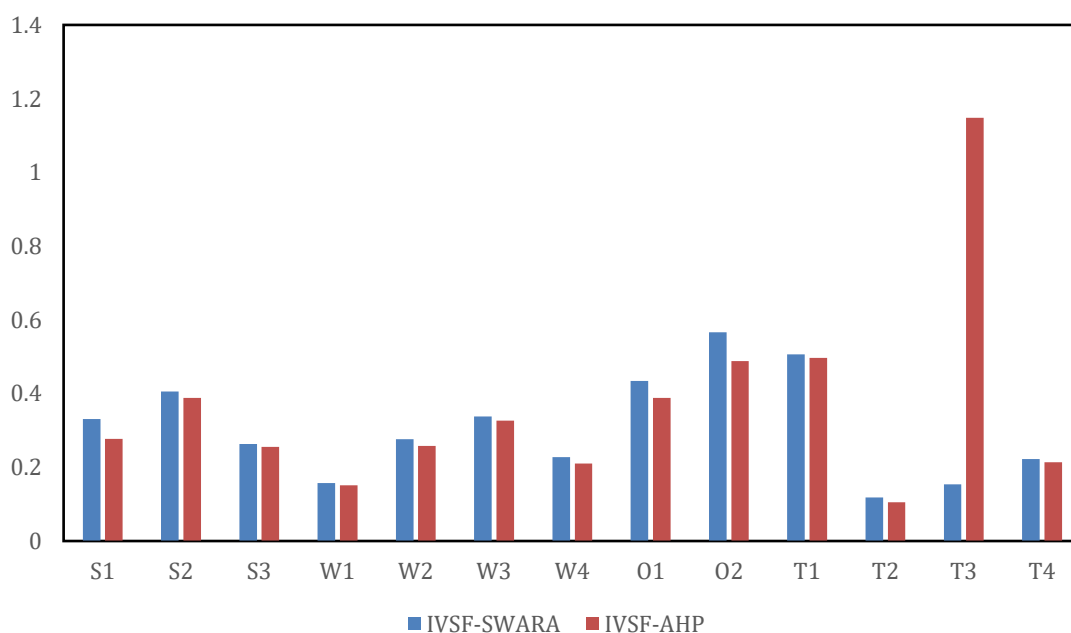


Fig. 1. A comparative analysis result

6. Findings and discussion

In this study, the evaluation of the AI role in reaching gender equality through a SWOT analysis is carried out. Via the framework, the most important factors that either enable or impede this ending are provided: AI reduces gender bias in recruitment (S2), biased AI reinforces gender inequalities (W3), AI detects harassment and supports legal protection (O2), and patriarchal norms hinder women's empowerment (T1). These findings are consistent with previous research showing that AI can support gender equality while also creating new risks when its design and governance are inadequate [24]. Therefore, AI adoption for SDG5 requires both technological innovation and gender-responsive governance.

AI reduces gender bias in recruitment (S2) is considered the most important strength. This personally deals with one of the basics challenges for achieving SDG5, unequal opportunities to employment and career development. When planned and monitored adequately, AI can assess candidates according to experience, skills, and equitable qualifications rather than gender associated with stereotypes, aiding to diminish prejudicial hiring practices and enhance equitable recruitment decisions. This permits huge involvement of workforce, identical opportunities related to employment, and enhanced economic empowerment for women, all of which are main objectives of SDG5. Previous research similarly indicates that AI-supported recruitment can reduce some forms of gender discrimination when appropriately designed and monitored [25]. Practically, organizations should therefore combine AI recruitment with regular bias audits and human oversight.

Biased AI reinforces gender inequalities (W3) is considered the most critical weakness. This is due to the fact that AI systems focus on historical or unrepresentative data which generate and increase existing gender stereotypes and unfair practices in various fields. Rather than bridging the gaps, biased AI may thoroughly handicap women and other underrepresented groups, resulting in inadequate decisions and restricting same opportunities. This erodes the core goal in reaching gender equality (SDG5), emphasizing the necessity for transparent, fair, and accountable AI systems assisted by various datasets and uninterrupted bias monitoring. This finding agrees with recent research showing that AI-based recruitment systems can reproduce existing gender stereotypes and inequalities [26]. Thus, continuous bias monitoring, representative datasets, and transparent AI systems are essential for supporting SDG5.

AI detects harassment and supports legal protection (O2) represent the most important opportunity. It can improve the response, prevention, and report related to gender-based violence, which constitute a main challenge in reaching gender equality (SDG5). By examining huge quantity of digital content and user reports, AI can quickly pinpoint patterns of online abuse, cyber harassment, and discriminatory behavior, permitting adequate intervention by relevant authorities and organizations. Additionally, AI-powered tools can help victims through evidence collection, legal guidance, and access to support services, enhancing the efficiency and accessibility of justice. Previous research shows that computational and AI-based approaches can support the detection of gender-based violence in digital communication [27]. In practice, such tools can assist authorities and support organizations in identifying harmful behavior earlier, while maintaining privacy and human verification.

Patriarchal norms hinder women's empowerment (T1) are considered the most critical threat because deeply rooted social and cultural biases can limit women's access to leadership roles, employment opportunities, digital education, and AI technologies, thereby diminishing the success of AI-driven measures that promote gender equality. Even when AI solutions are designed to support women's empowerment, discriminatory norms may influence their development, deployment, and acceptance, reinforcing existing inequalities rather than eliminating them. This finding is consistent

with research showing that sociocultural and patriarchal barriers can limit women's access to digital technologies and opportunities [28]. Therefore, AI-based SDG5 initiatives should also promote women's digital skills, access, and participation in AI-related decision-making.

7. Conclusions and future recommendations

This research employs an interval-valued spherical fuzzy methodology to explore and prioritize the SWOT factors influencing the application of AI in supporting the achievement of SDG5. Based on an extensive examination of the relevant literature, 13 factors were extracted and subsequently assessed using the evaluations provided by four experts with relevant knowledge and experience. The results identify the significant factor in each SWOT dimension, offering a comprehensive understanding of the potential contributions and challenges associated with AI-driven approaches for promoting SDG5.

Despite the contributions of this study, some limitations warrant further consideration. First, the analysis is conducted from a broad global perspective, which may overlook variations in regulatory environments, cultural norms, and institutional capacities that influence AI adoption across different geographical settings. Second, there is a few numbers of experts that are engaged in providing evaluations, which influence the generalizability of the findings. To overcome these limitations, future studies should increase the number of experts with various backgrounds. Moreover, comparative analyses between specific countries or geographical areas will offer greater insights into the contextual factors influencing AI implementation for SDG5.

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Conflicts of Interest

The authors declare no conflicts of interest.

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