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The Impact of AI in Sdg Implementation: A Delphi Study

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Abstract: Artificial Intelligence (AI) emerges as a powerful catalyst poised to reshape the global sustainability landscape by facilitating the attainment of Sustainable Development Goals (SDGs). This comprehensive Delphi study meticulously probes the insights of domain experts, shedding light on the strategic utilization of AI to advance these critical sustainability objectives. Employing rigorous statistical techniques, encompassing measures of central tendency and interquartile deviation, this research scrutinizes consensus dynamics among experts and elucidates potential variations in their viewpoints. The findings resoundingly convey experts' collective positive perspective regarding AI's pivotal role in propelling the SDGs forward. Through two iterative rounds of extensive discussions, a compelling consensus crystallizes—AI indeed exerts an overall positive impact, exemplified by a robust mean score of 78.8%. Intriguingly, distinct SDGs manifest varied propensities toward AI intervention, with Goals 6, 7, 8, 9, 11, 13, 14 and 15 basking in the radiance of highly positive impacts. Goals 1, 2, 3, 4, 5, 10 and 12 exhibit positive impact scores, indicating a juncture ripe for positive advancements. Meanwhile, Goal 16 and Goal 17 languish with neutral scores, signifying a juncture demanding nuanced deliberations about AI's impact on peace, justice, and strong institutions as well as on partnerships for the goals respectively. This paper underscores AI as a formidable instrument poised to address humanity's most pressing challenges while harmonizing seamlessly with the overarching SDG objectives. It gracefully dovetails into established practices across pivotal domains such as health, education, and resilient infrastructures, amplifying the collective global endeavor to navigate the path toward a more sustainable future.

Keywords: Artificial Intelligence; sustainable development goals; Delphi study; global sustainability; consensus

1. Introduction

The United Nations' Sustainable Development Goals (SDGs) delineate a global imperative to confront and mitigate the most urgent social, economic, and environmental dilemmas that threaten our world's equilibrium by the year 2030 [1]. These goals are not just aspirations; they are a blueprint for collective action, demanding innovative approaches and transformative technologies to drive progress. This era is witnessing the convergence of such transformative technology – Artificial Intelligence (AI) – with the SDGs, heralding an unparalleled prospect to tackle intricate barriers that obstruct the path toward realizing sustainable development [2]. Amidst this ambitious global agenda, Artificial intelligence, typified by its prowess in mimicking human cognitive functions, has undergone a significant renaissance in recent epochs. This resurgence, propelled by seminal

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innovations in machine learning, natural language processing, computer vision, and robotics, has catalyzed transformative shifts across diverse sectors and redefined societal paradigms [3]. This renaissance in AI technology positions it as a potent ally in achieving the SDGs. Standing at the intersection of cutting-edge technology and global sustainability, the ability of AI to sift through colossal data sets, discern intricate patterns, and extract actionable insights has been demonstrated as a pivotal mechanism in unlocking novel avenues for sustainable growth [4]. By amplifying human faculties, AI equips policymakers with empirical insights to craft targeted policies and interventions aligned with specific SDG objectives. Moreover, AI-infused analytics furnishes the means to gauge progress with precision, pinpoint deficiencies, and fine-tune strategies dynamically, thereby amplifying the efficacy of developmental endeavors [5]. This technological prowess transforms AI into a powerful tool for both monitoring and advancing the SDGs. Within the SDGs' framework, AI unfolds a spectrum of diverse solutions encompassing all 17 goals [6]. Ranging from poverty alleviation and healthcare enhancement to climate change mitigation and gender parity, AI methodologies harbor the potential to redress prevailing challenges and instigate pioneering solutions [7]. In essence, AI can be a double-edged sword, capable of both enabling and impeding the realization of SDGs, thereby underscoring the significance of an inclusive and rights-based approach to digital transformation [8]. The United Nations Development Programme (UNDP) has underscored the pivotal importance of evaluating countries' readiness for the adoption of AI and the establishment of robust data governance frameworks to facilitate the responsible deployment of AI in support of the SDGs [9]. International agreements and frameworks provide invaluable guidance on ensuring the ethical development of AI, particularly within the context of advanced nations [10]. These agreements serve as the bedrock upon which ethical integration of AI technologies is promoted [11]. Assessing readiness for AI adoption and fostering the responsible development of AI stand as pivotal steps in the effective incorporation of AI into sustainable development endeavors [12]. [7] provide relevant evidence suggesting that AI may act as an enabler across 134 targets (79%) encompassing all SDGs, primarily through technological advancements that can potentially overcome existing limitations. However, it's important to acknowledge that 59 targets (35%), distributed across all SDGs, may experience adverse consequences stemming from AI development [7]. The SDGs are classified into three overarching categories, corresponding to the pillars of sustainable development, namely Society, Economy, and Environment [13]. After numerous studies on the impact of AI on sustainability, many firms infuse AI into developing their products to improve their SD practices [14]. Nevertheless, it is essential to note that studies supporting AI as an enabler or inhibitor for SDGs were conducted within controlled environments, rendering it challenging to extrapolate these findings to real-world scenarios [7]. Given the ever-evolving societal, environmental, and economic dynamics, maintaining a dynamic feedback loop with AI remains imperative [15]. Collaborative efforts and ongoing impact assessments are critical to maximizing the benefits of AI while aligning with the SDGs. Nations at the forefront of AI adoption demonstrate their potential to foster economic growth and improve livelihoods, thus signaling the importance of actively embracing AI technologies [16]. For the 17 Goals; starting with SDG 1, No Poverty, AI holds promise in identifying impoverished areas and tailoring interventions. However, it's a dual-edged sword as concerns about potential job losses due to automation arise. Striking a balance between economic advancement and social well-being becomes imperative [7]. Moving to SDG 2, Zero Hunger, AI's ability to enhance agricultural productivity through precision farming is valuable. Yet, applying it effectively in resource-limited regions presents notable challenges. To truly address hunger, AI-driven solutions must reach those who need them the most [7,17]. In the realm of SDG 3, Good Health and Well-being, AI's role in advancing disease diagnosis and treatment holds immense potential. However, it must navigate privacy concerns associated with patient data. Balancing technological advancement with ethical considerations is crucial in this context [7,17]. SDG 4, Quality Education for all, sees promise in personalized learning with AI [18]. But it also raises concerns about exacerbating inequality if access remains uneven. Ensuring equitable access to educational AI tools is pivotal in achieving this goal [7,18]. In the context of SDG 5, Gender Equality, AI's capacity to identify and rectify biases within systems is valuable. Yet, meticulous management is crucial to avoid perpetuating existing societal

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biases. To promote gender equality effectively, AI must be a tool for empowerment and not discrimination [19]. SDG 6, Clean Water and Sanitation, benefits from AI in predicting water shortages and managing resources. However, challenges related to costs and data limitations may hinder widespread implementation. Addressing these challenges is essential to ensure access to clean water for all [20]. SDG 7, Affordable and Clean Energy, sees AI's role in enhancing energy efficiency as commendable. However, the energy-intensive nature of large-scale AI systems necessitates attention. Striking a balance between energy efficiency and environmental impact is critical [21,22]. Regarding SDG 8, Decent Work and Economic Growth, AI's potential to drive economic growth through new industries is noteworthy [23]. Nevertheless, addressing job displacement due to automation is essential. Supporting workforce transitions is vital in this journey towards equitable economic prosperity [16]. In the context of SDG 9, Industry, Innovation, and Infrastructure, AI's contributions to innovation and productivity are valuable [24]. However, careful consideration is necessary to prevent potential job displacement in certain sectors. Innovation must be coupled with strategies for inclusive growth [7,16,24]. Moving to SDG 10, Reduced Inequalities, AI's ability to identify patterns of inequality holds significance [25]. Yet, managing its implementation cautiously is imperative to prevent the exacerbation of the digital divide [26]. Bridging the gap between AI haves and have-nots is a key challenge [27]. SDG 11, Sustainable Cities and Communities, benefits from AI's optimization of urban planning and management [28]. Nonetheless, challenges in resource-poor settings may limit its full potential. Tailoring AI solutions to suit diverse urban contexts is vital in building sustainable communities [29]. While AI enables more efficient resource utilization for SDG 12, Responsible Consumption and Production, concerns exist about its potential contribution to increased consumption and waste [25]. Striking a balance between efficiency gains and responsible consumption is essential [30]. In SDG 13, Climate Action, AI's capacity to model and predict climate change impacts aligns well. Still, careful consideration must be given to its energy usage. Developing energy-efficient AI solutions is crucial in the fight against climate change [31]. SDG 14, Life Below Water, finds AI's role in monitoring marine pollution and aiding conservation efforts [25]. However, practical implementation and data collection remain challenging. Overcoming these obstacles is pivotal in protecting our oceans and marine ecosystems [25,32]. Similarly, SDG 15, Life on Land, benefits from AI's role in monitoring deforestation and supporting conservation efforts [33]. Yet, data limitations may affect its effectiveness. Enhancing data collection and analysis capabilities is essential for preserving terrestrial ecosystems [32,33]. For SDG 16, Peace, Justice, and Strong Institutions, AI's assistance in conflict prediction and justice delivery holds value [34]. Nevertheless, ensuring its responsible use in surveillance and privacy is essential. Safeguarding human rights and ethical AI deployment must go hand in hand [35]. Finally, in SDG 17, Partnerships for the Goals, AI's potential to enhance collaboration through data sharing and analysis is valuable [36]. However, addressing unequal access to AI technology is crucial to prevent the exacerbation of inequalities. Building inclusive partnerships is fundamental to achieving shared global objectives [37]. In each SDG, AI presents opportunities and challenges, reminding us of the need for responsible and equitable AI deployment in our journey towards a sustainable and prosperous future [38]. The establishment of a coherent policy framework is pivotal in promoting the adoption of AI to support the Sustainable Development Goals (SDGs). Such a framework should encompass data governance, capacity building, and a robust regulatory structure tailored to local norms. This research aims to dissect the symbiotic relationship between AI and the SDGs, exploring both the promises and pitfalls of this transformative partnership. Recommendations are proffered to policymakers, stakeholders, and practitioners to harness AI's potential in steering sustainable development. By judiciously embracing AI, while adhering to principles of inclusivity, equity, and sustainability, countries can traverse the intricacies of the contemporary epoch and forge a thriving and inclusive future for all.

2. Materials and Methods

A qualitative perspective was employed as the philosophical stand for the study, given its exploratory nature. The Delphi technique was specifically adopted for the study. This approach encompasses the identification of the research problem, followed by the selection of an expert panel

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and briefing of the experts about the process. According to previous research, the Delphi method is a qualitative methodological approach aimed at achieving consensus among a group of experts on a particular subject [39,40]. For this study, the Delphi technique was applied through two rounds of data collection: the exploratory phase of brainstorming, and the validation and consensus phase of redefining and prioritizing suggested ideas. These were followed by qualitative and quantitative analyses at the end of the first and second rounds. The process culminated in the interpretation of insights and presentation of results, outlining a convergence of opinions from the panel of experts [41]. The adoption of AI for SDG targets and goals are deliberated on respectively. Once a good consensus has been reached, an overall perspective of the experts is given for the complete potential contribution of AI to the SDGs. The conceptual framework (as shown in Figure 1) shows how the study would be carried out.

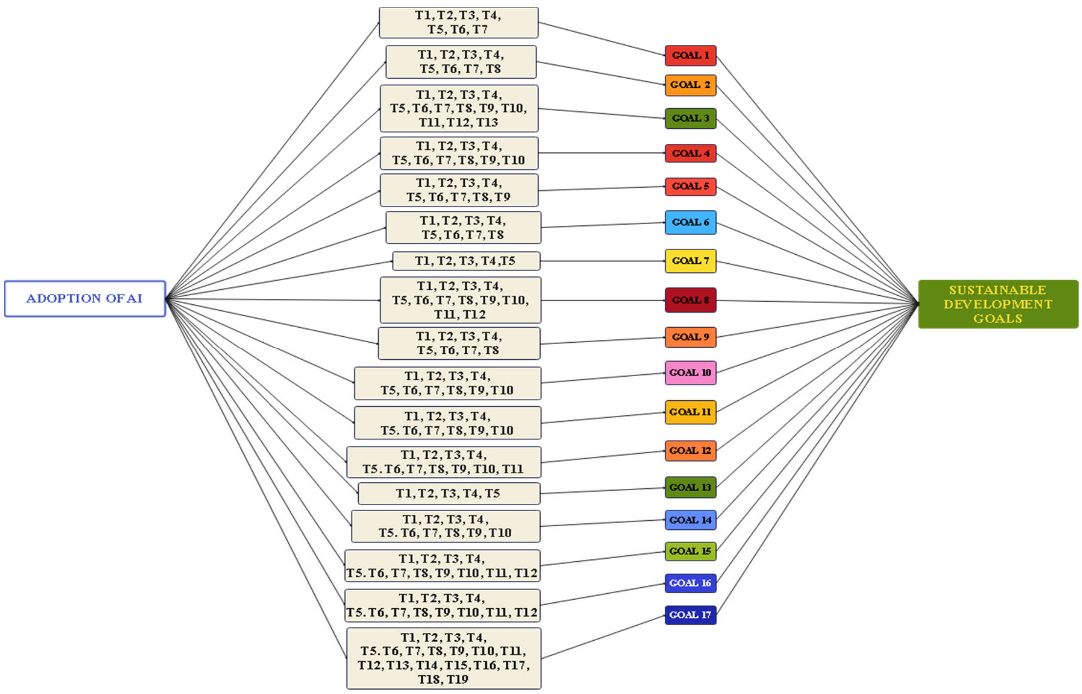

Figure 1. The Conceptual Framework for the Study.

2.1. Selection of Delphi Experts

The assembly of the expert panel for the Delphi study on the impact of AI on achieving the Sustainable Development Goals (SDGs) was a meticulously crafted process, following a systematic sequential sampling approach. The selection criteria were anchored on the qualifications and experience of professionals within the sustainability and SDGs sphere, with a particular focus on their insights into the future implications of AI in this context. The selection of experts for a Delphi panel is a nuanced process, often characterized by flexibility and adaptability to specific research objectives [42]. In this study, expertise was evaluated based on years of engagement in sustainability practices and a self-assessed understanding of the SDGs. Notably, basic knowledge of AI and its application was a prerequisite in the selection. of the experts. The impartial selection of participants was paramount, especially considering the study's focus on forthcoming global advancements. The number of participants within a Delphi panel is not rigidly defined, allowing for a diverse assembly of competent professionals [40,43]. Even within a compact group, the insights can be substantial and enriching. In this specific study, 15 professionals from various regions, including the United States, the United Kingdom, Singapore, Ghana, and South Africa, were invited. Most panelists possessed over 8 years of experience in sustainability and SDGs, and basic knowledge of AI and its applications representing a wide array of industries. This diverse panel, with varying familiarity with AI, was carefully curated to articulate astute opinions on the integration of AI within sustainability projects.

The selection process was guided by a well-defined yardstick, assessing predetermined criteria in collaboration with the demographic details of the potential panel experts. The stipulated requirements included possession of a minimum academic qualification in sustainability-related fields, professional experience, well-established knowledge of sustainability practices, and current engagement in relevant establishments or academia [44]. The recruitment process involved sending out invitations to 32 potential panel members, with 15 showing interest in partaking in the Delphi study. After the first round, 12 experts returned their questionnaires, engaging in all rounds of the study. The background information on the experts is detailed in Table 1. This selection process, aligning with previous studies [44,45], ensures a balanced and insightful exploration of the impact of AI on achieving the SDGs.

2.2 Delphi Cycles

Historical precedent consistently points to a recurring trend in the requisite number of cycles to effectively execute a Delphi study [46]. In the context of this study, a consensus was reached after two cycles, with each cycle spanning a month duration meticulously designed to afford panelists ample time to contribute substantively to the Delphi investigation. The initial cycle's research instrument was expertly crafted through the combination of pertinent literature germane to the subject matter. In contrast, the second round's instrument was meticulously shaped by insights garnered from experts during the initial round. Thus, the questionnaire for the second Delphi cycle emerged as a product of the collective brainstorming engaged in by panelists during the previous cycle. Given that AI's role in achieving SDGs remains novel and transformative, an open-ended question format was chosen to provide participants with the liberty to conceive innovative ideas. This phase generated an expansive dataset, which was subsequently subjected to rigorous analysis employing a qualitative thematic approach. This methodological choice subsequently laid the foundation for designing the questionnaire for the second Delphi cycle. Throughout each cycle, the perspectives of the experts were subjected to meticulous analysis, yielding insights into the consensus spectrum embedded within their responses. The second cycle introduced experts to a structured questionnaire, allowing panelists to assess the outcomes derived from the initial Delphi cycle. Subsequently, the feedback from the second cycle underwent rigorous scrutiny to ascertain the establishment of consensus on the topics under scrutiny.

Table 1. Background Information of Experts.

Demographic designation	**Number of experts**	**Percentage**
Academic qualifications		
Bachelor's degree	2	16.67%
Master's degree	6	50.00%
Doctor of philosophy	4	33.33%
Total	**12**	**100%**
Area of specialization		
Environmental sustainability and conservation, biodiversity, and climate action	3	25.00%
Urban planning and infrastructure	4	33.33%
Agriculture, health, and food security	2	16.67%
AI developers/ scientists/ enthusiasts	2	16.67%
AI Data Science and Analytics	1	8.33%
Total	**12**	**100%**
Years of experience		
1-5 years	2	16.67%

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6-10 years	7	58.33%
11-15 years	2	16.67%
Over 15 years	1	8.33%
Total	12	100%
Employment agency		
Academia	6	50.00%
Government Agency	2	16.67%
NGO/ International Bodies/ CSO	2	16.67%
Consultancy	1	8.33%
Private Organization	1	8.33%
Total	**12**	**100%**

2.3. Achieving Consensus

Attaining consensus from a diverse range of opinions is a complex endeavor. The process to reach consensus in a Delphi study doesn't have a universally defined path. [47] and [48] argue that consensus, synonymous with an agreement, arises from the collective projection of insights—matching the subjective understanding of central tendencies or agreement within the perspectives shared by the panelists throughout the rounds forming the Delphi study. Previous studies have used diverse statistical approaches to establish consensus in a Delphi process. [49] used the mean item score and standard deviation, noting that a reduction in standard deviation across successive rounds indicated a higher likelihood of consensus. Other studies have also employed methods like the interquartile deviation (IQD) to determine consensus in Delphi studies [39,44]. Within this study's scope, a combination of IQD, mean item score and standard deviation was thoughtfully applied to ascertain consensus in subsequent Delphi rounds. The IQD approach involves calculating the absolute difference between the 75th and 25th percentiles. Percentiles represent test values without a reference. Across any distribution, the 25th percentile (Q1), the 50th percentile (Q2) or median, and the 75th percentile (Q3) play key roles. Following Aigbavboa's insights, a minimal IQD value signifies heightened consensus, while a substantial value indicates reduced consensus [50]. The criteria for assessing consensus in this study are concisely summarized in Table 2 below. This comprehensive framework ensures a thorough consensus evaluation, enhancing the result of the study's credibility and validity.

Table 2. Criteria for Assessing Consensus.

Status of Consensus	Interquartile Deviation (IQD)
Weak consensus	$\geq 2.1 \leq 3$
Good consensus	$\geq 1.1 \leq 2$
Strong consensus	$\geq 0.0 \leq 1$

2.4. Determining Reliability and Validity of the Delphi Process

Ensuring the reliability of a Delphi process's outcomes is contingent upon the validity and consistency of the data set used. Yet, achieving a dependable and valid Delphi process remains a formidable challenge in any Delphi research. [51] posited that reliability is the degree to which a method consistently yields similar results under unchanged conditions. Given that Delphi studies are seen as a qualitative research approach, establishing their reliability and validity becomes intricate, especially when results are anchored on the intuitive insights derived from the panelists' understanding and perspective on AI and SDGs. However, this obstacle can be surmounted by providing a clear and comprehensive explanation of the procedure to potential panelists and by elucidating the core purpose of the process [52]. Considering this research, transparency

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communicated its objectives to the AI and SDG experts forming the Delphi panel. This clarity was achieved by meticulously presenting all the targets and goals of the 17 SDG goals with all the possible AI applications and uses. Additionally, a comprehensive guide on navigating the Delphi questionnaire was shared with the experts. [44] posits that the expert selection phase in a Delphi study acts as a validity measure. As such, rigorous attention was given to the expert selection phase, ensuring their aptness for the study's goals.

3. Results

3.1. Delphi Round One Result

The initial round of the Delphi study gathered responses from the expert panel on the impact of AI on achieving the SDGs. There was an opportunity for the inclusion of measures not initially captured in the survey by the experts. The study utilized a ten-point Likert scale, spanning from Highly negative impact to Highly positive impact. The results of the first round of the Delphi study are presented in Table 3. This table showcases the findings of the mean, median, standard deviation, and IQD. The validity and reliability of the research instrument were ascertained using the Cronbach Alpha test. This yielded a value of 0.96 for the targets, 0.89 for the goals and 0.898 for the total contribution of AI, which suggests commendable validity and reliability of the research instrument for the Delphi study, as the value tends towards 1.00. The mean and median scores ranged between 8-10 for highly positive impact, 6-7.99 for positive impact, 5-5.99 for neutral impact, 3-4.99 for negative impact and 1-2.99 for highly negative impact. The mean scores and median scores assist in discovering the central tendency of the respondents. Hence, for the goal and target scores which contained outliers from the views of the respondents, both the mean and median were used to determine the complete outlook of the perspectives of the respondents. In the context of AI's impact on achieving the SDGs, the experts identified four goals with a highly positive impact of AI (very high score of the means: 8.00–10.00) goals. These include Goals 1, 3, 9, and 16. The lowest scores were within the neutral range which included goals 6,10,13 and 14. In the first round of the Delphi study, there was a strong consensus reached among the experts. The IQD results from the findings indicate they were within the range of 0.3 and 1.5. However, due to some varying views and feedback, a second discussion was required to ensure a higher consensus. This study underscored the importance of understanding the influence of AI on each of the targets of the 17 goals and emphasizes the need for continued dialogue and research in this domain.

Table 3. Results of Round One of the Delphi Study.

Goal/Targets(T)	Median	Mean	SD	IQD
Goal 1	**8.00**	**8.00**	**0.70**	**1.000**
T1	8.04	8.00	0.65	1.000
T2	6.67	6.67	0.49	0.500
T3	5.42	5.42	0.48	0.750
T4	6.67	6.67	0.49	0.500
T5	8.67	8.67	0.58	1.000
T6	4.42	4.42	0.48	0.500
T7	2.92	2.92	0.49	0.500
Goal 2	**7.17**	**7.00**	**0.85**	**1.200**
T1	8.00	8.21	0.63	1.000
T2	7.00	6.67	0.49	0.375
T3	5.50	5.42	0.48	0.375
T4	7.00	7.08	0.47	0.500

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T5	8.50	8.58	0.58	1.000
T6	4.50	4.42	0.48	0.250
T7	3.00	2.92	0.49	0.125
T8	7.50	7.67	0.48	0.375
Goal 3	**8.00**	**8.00**	**0.70**	**1.000**
T1	8.50	8.46	0.50	0.750
T2	7.00	6.71	0.47	1.000
T3	5.00	5.04	0.52	0.500
T4	7.00	6.96	0.48	0.500
T5	7.75	7.79	0.49	1.250
T6	4.00	3.96	0.52	1.000
T7	3.00	2.96	0.48	1.000
T8	7.00	6.79	0.24	0.500
T9	7.75	7.67	0.48	1.000
T10	7.00	6.67	0.49	1.500
T11	5.75	5.67	0.49	1.000
T12	4.75	4.67	0.49	1.500
T13	7.75	7.67	0.48	0.500
Goal 4	**6.67**	**7.00**	**0.57**	**0.750**
T1	8.50	8.46	0.50	0.375
T2	7.00	6.71	0.47	0.625
T3	5.00	5.04	0.52	0.750
T4	7.00	6.96	0.48	0.375
T5	7.75	7.79	0.49	0.500
T6	4.00	3.96	0.52	1.250
T7	3.00	2.96	0.48	0.750
T8	7.00	6.79	0.24	0.500
T9	7.75	7.67	0.48	0.500
T10	7.00	6.67	0.49	0.500
Goal 5	**7.08**	**7.00**	**0.64**	**1.000**
T1	8.00	7.92	0.35	0.375
T2	5.75	5.75	0.42	0.375
T3	4.50	4.42	0.48	0.500
T4	6.00	6.08	0.57	0.500
T5	7.00	6.92	0.48	0.500
T6	3.00	3.08	0.48	0.500
T7	2.00	2.08	0.42	0.500
T8	5.75	5.75	0.25	0.500
T9	6.75	6.67	0.48	0.500
Goal 6	**6.00**	**6.00**	**0.75**	**1.000**
T1	8.00	7.92	0.35	0.500
T2	5.75	5.75	0.42	0.500

T3	4.50	4.42	0.48	0.500
T4	6.00	6.08	0.57	0.500
T5	7.00	6.92	0.48	0.500
T6	3.00	3.08	0.48	0.500
T7	2.00	2.08	0.42	0.500
T8	5.75	5.75	0.25	0.500
Goal 7	**7.83**	**8.00**	**0.78**	**1.250**
T1	8.00	8.00	0.35	1.000
T2	6.50	6.42	0.42	1.000
T3	5.50	5.42	0.42	0.500
T4	7.00	7.00	0.35	1.000
T5	7.50	7.50	0.42	1.000
Goal 8	**7.42**	**7.00**	**0.57**	**1.000**
T1	8.00	8.00	0.35	1.000
T2	6.50	6.42	0.42	1.000
T3	5.50	5.42	0.42	0.500
T4	7.00	7.00	0.35	1.000
T5	7.50	7.50	0.42	1.000
T6	4.00	4.00	0.35	1.000
T7	4.45	4.42	0.42	0.500
T8	6.00	6.00	0.35	1.000
T9	7.00	7.00	0.35	1.000
T10	7.50	7.50	0.42	1.000
T11	8.50	8.42	0.42	1.000
T12	8.00	8.00	0.35	1.000
Goal 9	**8.17**	**8.00**	**0.79**	**1.000**
T1	8.00	8.00	0.35	1.000
T2	6.50	6.42	0.42	0.500
T3	5.50	5.42	0.42	0.500
T4	7.00	7.00	0.35	0.500
T5	7.50	7.50	0.42	0.500
T6	4.00	4.00	0.35	0.500
T7	4.50	4.50	0.42	0.500
T8	6.00	6.00	0.35	0.500
Goal 10	**6.75**	**7.00**	**0.58**	**0.750**
T1	8.00	8.00	0.35	1.000
T2	6.50	6.42	0.42	1.000
T3	5.50	5.42	0.42	1.000
T4	7.00	7.00	0.35	1.000
T5	7.50	7.50	0.42	1.000
T6	4.00	4.00	0.35	1.000
T7	4.50	4.42	0.42	1.000

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T8	6.00	6.00	0.35	1.000
T9	7.00	7.00	0.35	1.000
T10	7.50	7.50	0.42	0.500
Goal 11	**7.42**	**7.50**	**0.63**	**1.000**
T1	8.00	8.00	0.35	1.000
T2	6.50	6.42	0.42	1.000
T3	5.50	5.42	0.42	1.000
T4	7.00	7.00	0.35	1.000
T5	7.50	7.50	0.42	1.000
T6	4.00	4.00	0.35	1.000
T7	4.50	4.42	0.42	1.000
T8	6.00	6.00	0.35	1.000
T9	7.00	7.00	0.35	1.000
T10	7.50	7.50	0.42	0.500
Goal 12	**7.42**	**7.50**	**0.64**	**1.000**
T1	8.00	8.00	0.35	1.000
T2	6.50	6.42	0.42	1.000
T3	5.50	5.42	0.42	1.000
T4	7.00	7.00	0.35	1.000
T5	7.50	7.50	0.42	1.000
T6	4.00	4.00	0.35	1.000
T7	4.50	4.42	0.42	1.000
T8	6.00	6.00	0.35	1.000
T9	7.00	7.00	0.35	1.000
T10	7.50	7.50	0.42	0.500
T11	8.50	8.42	0.42	1.000
Goal 13	**6.42**	**6.50**	**0.50**	**0.750**
T1	7.00	7.00	0.35	1.000
T2	7.50	7.67	0.42	0.500
T3	8.50	8.67	0.42	1.000
T4	7.00	7.00	0.42	1.000
T5	7.50	7.67	0.35	1.000
Goal 14	**6.75**	**6.50**	**0.56**	**0.750**
T1	7.00	7.00	0.35	1.000
T2	7.50	7.67	0.42	0.500
T3	8.50	8.67	0.42	1.000
T4	7.00	7.00	0.35	1.000
T5	7.50	7.67	0.42	1.000
T6	8.50	8.67	0.42	1.500
T7	7.50	7.67	0.42	1.000
T8	8.50	8.67	0.42	1.000
T9	7.50	7.67	0.42	1.000

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T10	7.50	7.67	0.42	1.000
Goal 15	**7.83**	**8.00**	**0.62**	**1.000**
T1	7.00	7.00	0.35	0.500
T2	7.50	7.67	0.42	0.500
T3	8.50	8.67	0.42	1.000
T4	7.00	7.00	0.35	0.500
T5	7.50	7.67	0.42	0.500
T6	8.50	8.67	0.42	1.000
T7	7.50	7.67	0.42	0.500
T8	8.50	8.67	0.42	1.000
T9	7.50	7.67	0.42	0.500
T10	7.50	7.67	0.42	0.500
T11	7.00	7.00	0.35	1.000
T12	8.00	8.00	0.35	1.000
Goal 16	**8.00**	**8.00**	**0.58**	**1.000**
T1	7.00	7.00	0.35	0.500
T2	7.50	7.67	0.42	0.500
T3	8.50	8.67	0.42	0.000
T4	7.00	7.00	0.35	0.500
T5	7.50	7.67	0.42	0.500
T6	8.50	8.67	0.42	0.000
T7	7.50	7.67	0.42	0.500
T8	8.50	8.67	0.42	0.500
T9	7.50	7.67	0.42	0.500
T10	7.50	7.67	0.42	0.500
T11	7.00	7.00	0.35	0.500
T12	8.00	8.00	0.35	0.000
Goal 17	**7.75**	**8.00**	**0.50**	**1.000**
T1	8.00	8.00	0.35	1.000
T2	6.50	6.42	0.42	0.500
T3	5.50	5.42	0.42	1.000
T4	7.00	7.00	0.35	0.500
T5	7.57	7.50	0.42	1.000
T6	7.00	7.08	0.42	0.500
T7	7.50	7.42	0.42	0.500
T8	8.50	8.42	0.42	1.000
T9	6.50	6.50	0.35	1.000
T10	7.50	7.42	0.42	0.500
T11	6.50	6.67	0.42	0.250
T12	7.50	7.67	0.42	0.250
T13	8.50	8.67	0.42	0.250
T14	7.00	7.00	0.35	0.250

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T15	7.50	7.67	0.42	0.250
T16	8.50	8.67	0.42	0.250
T17	7.50	7.67	0.42	0.250
T18	8.50	8.67	0.42	0.250
T19	7.50	7.67	0.42	0.250
Cronbach alpha:	**Goal:** 0.89		**Target:** 0.96	

Total Goal contribution	Mean	Median	SD	IQD
All Goal contributions	7.28	7.25	0.50	0.600
Cronbach alpha:		0.898		

3.2. Delphi Round Two Result

Table 4 presents the findings from the second round of the Delphi study involving the experts who participated in the initial round. After careful deliberation from the responses of the first results, a second round of the study was conducted. This ensured a higher consensus of the expert views and perspectives.

Table 4. Results of Round Two of the Delphi Study.

Goal/Targets (T)	Median	Mean	SD	IQD
Goal 1	**7.05**	**7.00**	**0.32**	**0.600**
T1	6.98	6.90	0.29	0.550
T2	7.02	7.02	0.28	0.530
T3	6.99	6.95	0.31	0.570
T4	7.05	7.04	0.27	0.520
T5	6.98	6.95	0.29	0.550
T6	7.00	6.99	0.28	0.540
T7	7.01	7.00	0.29	0.560
Goal 2	**7.05**	**7.00**	**0.20**	**0.400**
T1	7.05	7.04	0.22	0.410
T2	7.05	7.02	0.20	0.380
T3	7.05	7.02	0.20	0.375
T4	7.05	7.03	0.21	0.390
T5	7.05	7.02	0.22	0.400
T6	7.05	7.03	0.23	0.420
T7	7.02	7.00	0.21	0.380
T8	7.05	7.03	0.21	0.390
Goal 3	**7.04**	**7.00**	**0.21**	**0.350**
T1	6.96	6.95	0.28	0.520
T2	6.97	6.95	0.26	0.500
T3	6.98	6.90	0.28	0.530
T4	6.97	6.90	0.29	0.550
T5	6.96	6.90	0.27	0.520

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T6	6.94	6.90	0.26	0.500
T7	6.95	6.85	0.28	0.540
T8	7.00	6.79	0.24	0.500
T9	6.96	6.90	0.26	0.520
T10	7.02	7.00	0.29	0.520
T11	7.01	7.00	0.27	0.510
T12	7.05	7.00	0.28	0.530
T13	6.98	6.98	0.26	0.510
Goal 4	**7.05**	**7.00**	**0.20**	**0.400**
T1	7.01	7.00	0.29	0.530
T2	7.02	7.00	0.28	0.520
T3	7.00	6.99	0.29	0.530
T4	7.00	6.95	0.28	0.540
T5	7.00	6.99	0.27	0.530
T6	6.98	6.95	0.26	0.510
T7	6.97	6.90	0.28	0.540
T8	7.01	7.00	0.29	0.550
T9	7.00	6.99	0.27	0.510
T10	6.98	6.95	0.26	0.520
Goal 5	**7.00**	**6.98**	**0.15**	**0.150**
T1	7.01	7.00	0.19	0.350
T2	7.00	7.00	0.14	0.305
T3	7.00	7.00	0.12	0.290
T4	7.00	7.00	0.13	0.300
T5	7.01	7.00	0.12	0.290
T6	7.00	7.00	0.43	0.300
T7	7.00	7.00	0.12	0.290
T8	7.00	7.00	0.12	0.290
T9	7.00	7.00	0.12	0.300
Goal 6	**8.65**	**8.65**	**0.15**	**0.200**
T1	8.61	8.60	0.16	0.250
T2	8.70	8.69	0.12	0.150
T3	8.63	8.60	0.13	0.200
T4	8.71	8.70	0.13	0.200
T5	8.71	8.70	0.12	0.150
T6	8.76	8.70	0.10	0.150
T7	8.75	8.74	0.12	0.150
T8	8.75	8.75	0.11	0.200
Goal 7	**8.92**	**8.90**	**0.16**	**0.200**
T1	8.86	8.80	0.20	0.200
T2	8.90	8.89	0.15	0.200
T3	8.90	8.90	0.14	0.175

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T4	8.91	8.90	0.18	0.250
T5	8.90	8.90	0.17	0.200
Goal 8	**8.93**	**8.90**	**0.15**	**0.200**
T1	8.75	8.75	0.12	0.150
T2	8.75	8.75	0.11	0.150
T3	8.77	8.75	0.10	0.150
T4	8.80	8.76	0.10	0.150
T5	8.76	8.75	0.10	0.150
T6	8.96	8.95	0.17	0.225
T7	8.93	8.90	0.16	0.200
T8	8.96	8.95	0.16	0.225
T9	8.92	8.90	0.14	0.200
T10	8.92	8.90	0.13	0.175
T11	8.93	8.90	0.12	0.175
T12	8.92	8.90	0.11	0.150
Goal 9	**8.95**	**8.93**	**0.18**	**0.225**
T1	8.80	8.78	0.20	0.250
T2	8.80	8.77	0.18	0.200
T3	8.80	8.79	0.17	0.200
T4	8.80	8.76	0.19	0.225
T5	8.75	8.75	0.18	0.225
T6	8.75	8.70	0.15	0.200
T7	8.76	8.75	0.15	0.225
T8	8.80	8.76	0.14	0.200
Goal 10	**7.06**	**7.05**	**0.10**	**0.150**
T1	7.00	6.98	0.21	0.275
T2	6.95	6.95	0.9	0.225
T3	6.95	6.95	0.17	0.225
T4	6.96	6.95	0.18	0.200
T5	6.93	6.90	0.16	0.225
T6	6.92	6.90	0.16	0.225
T7	6.91	6.90	0.14	0.200
T8	6.92	6.90	0.15	0.200
T9	6.92	6.90	0.13	0.175
T10	6.91	6.90	0.12	0.175
Goal 11	**8.97**	**8.95**	**0.15**	**0.225**
T1	8.60	8.60	0.23	0.300
T2	8.60	8.60	0.22	0.250
T3	8.70	8.70	0.18	0.200
T4	8.60	8.60	0.19	0.225
T5	8.70	8.70	0.16	0.200
T6	8.70	8.70	0.16	0.200

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T7	8.70	8.70	0.14	0.175
T8	8.70	8.70	0.13	0.175
T9	8.65	8.65	0.14	0.200
T10	8.70	8.68	0.15	0.225
Goal 12	**7.10**	**7.07**	**0.09**	**0.150**
T1	6.96	6.95	0.14	0.200
T2	6.92	6.90	0.13	0.225
T3	6.93	6.90	0.13	0.175
T4	6.92	6.90	0.11	0.175
T5	6.93	6.90	0.12	0.200
T6	6.93	6.90	0.10	0.175
T7	6.92	6.90	0.10	0.175
T8	6.92	6.90	0.11	0.200
T9	6.91	6.90	0.10	0.175
T10	6.92	6.90	0.10	0.175
T11	6.91	6.90	0.08	0.175
Goal 13	**8.82**	**8.82**	**0.01**	**0.010**
T1	8.83	8.80	0.18	0.225
T2	8.82	8.80	0.15	0.200
T3	8.82	8.80	0.16	0.200
T4	8.81	8.80	0.14	0.225
T5	8.82	8.80	0.13	0.200
Goal 14	**8.88**	**8.87**	**0.10**	**0.200**
T1	8.73	8.70	0.20	0.250
T2	8.69	8.60	0.20	0.225
T3	8.72	8.70	0.17	0.200
T4	8.73	8.70	0.16	0.200
T5	8.80	8.79	0.15	0.225
T6	8.80	8.75	0.15	0.225
T7	8.71	8.70	0.18	0.225
T8	8.73	8.70	0.16	0.200
T9	8.72	8.70	0.14	0.225
T10	8.75	8.70	0.14	0.225
Goal 15	**8.93**	**8.90**	**0.16**	**0.200**
T1	8.65	8.65	0.15	0.200
T2	8.60	8.58	0.12	0.175
T3	8.61	8.60	0.13	0.200
T4	8.60	8.60	0.11	0.150
T5	8.62	8.60	0.13	0.175
T6	8.71	8.70	0.12	0,150
T7	8.72	8.70	0.11	0.175
T8	8.71	8.70	0.11	0.150

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T9	8.75	8.75	0.10	0.150
T10	8.72	8.70	0.09	0.125
T11	8.75	8.73	0.10	0.150
T12	8.71	8.70	0.10	0.150
Goal 16	**5.45**	**5.45**	**0.10**	**0.150**
T1	5.42	5.40	0.09	0.150
T2	5.42	5.40	0.09	0.150
T3	5.41	5.40	0.08	0.150
T4	5.43	5.40	0.10	0.150
T5	5.45	5.44	0.10	0.200
T6	5.43	5.40	0.10	0.150
T7	5.43	5.40	0.09	0.200
T8	5.45	5.45	0.10	0.150
T9	5.45	5.44	0.10	0.150
T10	5.45	5.45	0.10	0.150
T11	5.45	5.45	0.09	0.150
T12	5.45	5.45	0.10	0.150
Goal 17	**5.53**	**5.50**	**0.07**	**0.200**
T1	5.50	5.50	0.08	0.200
T2	5.40	5.40	0.10	0.200
T3	5.55	5.53	0.09	0.200
T4	5.50	5.50	0.10	0.300
T5	5.55	5.55	0.08	0.200
T6	5.50	5.50	0.08	0.200
T7	5.23	5.55	0.08	0.200
T8	5.50	5.50	0.07	0.200
T9	5.53	5.50	0.07	0.200
T10	5.53	5.50	0.07	0.200
T11	5.50	5.50	0.06	0.200
T12	5.53	5.50	0.06	0.200
T13	5.53	5.50	0.06	0.200
T14	5.50	5.50	0.07	0.200
T15	5.50	5.50	0.07	0.200
T16	5.50	5.50	0.07	0.200
T17	5.50	5.50	0.06	0.200
T18	5.50	5.50	0.07	0.200
T19	5.50	5.49	0.30	0.100
Cronbach alpha: **Goal:** 0.91			**Target:** 0.97	

Total Goal contribution	**Mean**	**Median**	**SD**	**IQD**
All Goal contributions	7.88	7.95	0.22	0.750

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Cronbach alpha:	0.94

The findings revealed that AI has a positive impact on the achievement of all 17 SDGs. Given the scale provided in Table 2, all 17 Goals achieved good consensus (IQD values ranging from 0.01 – 1.0, based on the expert opinions in the Delphi study). AI's impact on achieving the SDGs, the experts identified eight goals with highly positive impact of AI (very high score of the means: 8.00–10.00) goals. These include Goals 6, 7, 8, 9, 11, 13, 14 and 15. The lowest scores were within the neutral range which included goals 16 and 17 respectively. The validity and reliability test for the research instrument further confirmed the robustness of the findings with an alpha value of 0.97 for the targets, 0.91 for the goals and 0.94 indicating good reliability. The results according to table 4 above underscores the positive impact of AI in achieving the SDGs at the goal and target level, emphasizing the need for the development of a comprehensive approach when integrating AI strategies with sustainable development goals.

4. Discussion

Artificial Intelligence (AI) is recognized for its transformative potential across a myriad of domains. Its influence on the United Nations' Sustainable Development Goals (SDGs) is essential for both maximizing its benefits and addressing inherent challenges. Grounded in the Delphi approach, this study captures the expert consensus on the implications of AI for the SDGs. Through a Likert scale, the study delineates impacts, ranging from "Highly Positive Impact" (8-10) to "Highly Negative Impact" (1-2.99). Subsequent analysis presents the median, mean, standard deviation (SD), and interquartile deviation (IQD) for each goal meticulously. Starting with Goal 1, which focuses on eradicating poverty globally. The sentiment towards this goal has a positive impact, with a median score of 7.05 and a mean of 7. This aligns with the belief that AI can transform our approach to combating poverty, from using AI in precision agriculture to improve food security to leveraging predictive analytics to identify regions vulnerable to economic challenges. The standard deviation of 0.32 and interquartile deviation of 0.6 indicate that while there is a consensus for a positive impact on AI's role, experts are aware of its limitations and potential pitfalls. For example, AI can optimize resource allocation, but relying too heavily on AI without human discretion may lead to unforeseen challenges [53]. Looking at specific targets within Goal 1, Target 1.1 (T1) shows that AI can play a significant role in ensuring equitable access to economic resources, with median and mean scores of 6.98 and 6.9 respectively [54]. This suggests that AI can greatly improve resource distribution, making essentials accessible to marginalized sectors. Similarly, Target 1.2 (T2), with scores of 7.02 for both median and mean, indicates AI's potential to strengthen the resilience of economically vulnerable populations, particularly in anticipating natural or economic adversities. Target 1.3 (T3) scores of 6.99 and 6.95 for median and mean respectively highlight AI's potential to enhance resource mobilization for anti-poverty strategies [7,53,54]. Overall, the data for Goal 1 demonstrates that AI can have a significant positive impact on poverty eradication, but its deployment must be balanced and nuanced. Moving on to Goal 2, "No Hunger" and promoting sustainable agriculture, the data shows a positive impact and emphasizes the transformative potential of AI in sustainable development. This goal aims not only to feed the global population but to do so sustainably and efficiently. Examining the specific targets, Target 2.1 (T1) suggests that AI can play an instrumental role in guaranteeing access to nutritious food. By utilizing AI, food supply chains can be refined, wastage can be dramatically reduced, and nutritious food can be delivered promptly to those in need. Target 2.2 (T2), which likely focuses on sustainable agricultural methods, highlights the promise of AI even further [55]. Precision agriculture driven by AI can optimize resource usage, maximizing yield while minimizing environmental impact. Additionally, Target 2.3 (T3), which may center on enhancing local food production systems, reveals how AI can demystify local market dynamics. Producers can gain valuable insights into market demand, ensuring a harmonious balance between production and consumption [16,55]. Ensuring health and well-being for all (Goal 3) is also positively impacted by AI, as indicated by a mean score of 7. AI can be harnessed in various ways to strengthen global health [56]. AI-enhanced diagnostics and predictive algorithms can enable healthcare professionals to

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intervene early, reducing risks and improving maternal health outcomes [56]. Target 3.2 (T2), which possibly addresses the prevention and treatment of substance abuse, demonstrates the capabilities of AI. AI can enhance the precision of early detection of substance misuse and analyze vast datasets to provide tailored treatment recommendations, leading to more personalized and effective therapeutic approaches [56]. Furthermore, Target 3.3 (T3), potentially centered on reducing traffic-related fatalities, highlights the transformative potential of AI in urban planning and traffic management. AI-powered traffic systems can optimize mobility and significantly reduce accidents, ultimately saving lives. Goal 4, dedicated to enhancing inclusive and equitable quality education, stands out with its notable positive impact, reflected in mean and median scores of 7 and 7.05, respectively. This consensus among experts underscores the transformative potential of AI in the educational realm. AI emerges as a powerful tool for personalizing educational experiences, ensuring that learning is tailored to everyone's unique needs and circumstances [57,58]. This personalization extends to the adaptation of educational content, keeping pace with the evolving demands of the job market and ensuring learners are equipped with relevant, in-demand skills [57–59]. Transitioning to Goal 5, which is centered on the pivotal issues of gender equality and the empowerment of women and girls, the role of AI is again prominent. AI's data analysis capabilities shine in identifying and addressing areas of discrimination against women, providing a robust tool for promoting equality [60]. Beyond merely identifying issues, AI aids in the proactive detection of harmful practices, enabling timely intervention and the initiation of preventive measures [60]. This proactive approach is further evident in AI's contribution to promoting equitable representation in leadership roles, helping to identify and rectify gender biases within organizations. Water and sanitation (Goal 6), presents a compelling mean score of 8.65. This score reflects a robust consensus on AI's transformative role in this domain. AI's capabilities span from optimizing wastewater treatment to preserving water-related ecosystems [61,62]. Shifting the focus to Goal 6, dedicated to water and sanitation, resonates with a strong consensus on AI's transformative impact, as evidenced by its remarkable mean score of 8.65. The role of AI extends to the optimization of wastewater treatment processes, ensuring not only cleanliness but also the efficient repurposing of waste into valuable resources like biogas or fertilizers [61]. Furthermore, AI's role in the meticulous preservation and restoration of water-related ecosystems underscores its comprehensive capabilities in contributing to sustainable water and sanitation management [61,62]. Goal 7 emphasizes the importance of access to affordable and sustainable energy, with its median and mean scores of 8.92 and 8.9, respectively, showcasing a strong belief in AI's transformative role in the energy sector. AI's potential is evident in enhancing renewable energy sources and optimizing energy consumption through smart grids [63]. Additionally, AI's role in predicting equipment malfunctions and devising energy storage solutions highlights its significance in ensuring a consistent energy supply [64]. Goal 8, with mean and median scores of 8.9 and 8.93, focuses on sustainable economic growth and employment. AI's capabilities are highlighted in its ability to forecast job market trends, detect illicit activities such as forced labor, and ensure workplace safety [65]. This goal underscores AI's potential in promoting inclusive and sustainable economic growth. Goal 9, with a mean score of 8.93, emphasizes the construction of resilient infrastructure, sustainable industrialization, and the promotion of innovation. AI's transformative capacity is evident in revolutionizing construction processes, streamlining industrial operations, and guiding research and development based on global trends [7,66]. This goal portrays AI as a pivotal tool in reshaping infrastructure, industrialization, and innovation for a more resilient, sustainable, and inclusive future [67]. Goal 10, which addresses the reduction of inequalities, underscores AI's pivotal role in bridging disparities and fostering inclusivity. Target 10.1 (T1), for instance, highlights AI-driven financial instruments' ability to analyze financial trends, targeting regions or sectors that would benefit most from economic interventions. Target 10.2 (T2) emphasizes AI's monitoring capabilities, ensuring policies remain equitable and unbiased. Moreover, Target 10.3 (T3) accentuates AI's role in global migration management, guiding the formulation of policies that are both responsive and humane [68]. Goal 11, anchored in the vision of creating inclusive, safe, resilient, and sustainable cities, showcases a strong consensus on AI's monumental role in urban development. Target 11.1 (T1) demonstrates AI's potential in urban planning, optimizing spaces for equitable

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housing solutions [69]. Target 11.2 (T2), on the other hand, highlights AI's prowess in traffic management, ensuring fluid traffic flows and reduced emissions. Additionally, Target 11.3 (T3) accentuates AI's transformative role in disaster management, allowing city planners to institute preemptive measures [69]. Goal 12 champions sustainable consumption and production patterns. Target 12.1 (T1) emphasizes the sustainable management and efficient use of natural resources, with AI optimizing resource extraction and utilization [6]. Target 12.2 (T2) showcases AI as a crucial ally in predicting waste patterns and refining recycling processes. Concluding with Target 12.3 (T3), AI-driven insights assist businesses in crafting strategies that promote sustainability, fostering a culture of responsible consumption [6,70]. Climate Change (Goal 13) showcases a highly positive impact. The consensus among experts suggests that AI can be a pivotal tool in addressing climate challenges. AI's predictive capabilities can revolutionize policymaking, allowing for adaptive and proactive strategies. Its real-time monitoring can also be instrumental in orchestrating timely interventions in vulnerable zones, ensuring a coordinated global response to climate change [71,72]. Goal 14, dedicated to marine conservation, reflects a mean score of 8.87, indicating a highly positive impact. This score reflects a robust belief in AI's transformative role in marine health and sustainability [73]. AI's monitoring capabilities can track pollution sources, ensuring marine habitats remain pristine. Additionally, its insights into marine ecosystems can guide sustainable fishing practices, safeguarding marine biodiversity and ensuring the sustainable use of marine resources [32]. Goal 15, emphasizing terrestrial conservation, resonates with a mean score of 8.9 and a median of 8.93, suggesting a highly positive impact. AI's monitoring capabilities, combined with satellite imagery, can detect illicit activities like illegal logging and preserving forests. Additionally, AI's analytical prowess can direct reforestation efforts, reversing desertification trends, and bolstering terrestrial health [32,74]. Peace, Justice, and Strong Institutions (Goal 16) carries a neutral sentiment with a mean score of 5.45. This suggests that AI's role in this domain is diverse, with both potential benefits and challenges. Predictive capabilities of AI can aid in identifying crime hotspots, but there's caution against over-reliance or biases in AI algorithms [75,76]. In the realm of justice, AI can democratize access, but there's a call for transparency and unbiased tools. AI-driven governance tools promise enhanced accountability, but their deployment must be judicious and unbiased [75]. Goal 17, centered on strengthening global partnerships for sustainable development, also reflects a neutral stance with a mean score of 5.5. This indicates that while AI can enhance global partnerships, complexities must be addressed. Its neutral impact emphasizes the need for a harmonious blend of technology and human-driven initiatives [36]. While AI offers tools that can enhance collaboration, resource allocation, and trade, its neutral impact underscores the importance of striking a balance, ensuring that technology augments, rather than replaces, human-driven initiatives and partnerships [77]. The Sustainable Development Goals (SDGs) represent a collective vision for addressing global challenges, with AI emerging as a transformative tool in this pursuit. While AI has the potential to revolutionize areas like health (SDG3), education (SDG4), and resilient infrastructures (SDG9), as highlighted by [7,37] it also brings forth challenges. Respondents who disagreed with AI's impact on some SDGs such as 1, 2, and 9, cited examples from the tech and automobile industries, where AI has entirely automated the assembly of complex equipment, potentially leading to job displacement and poverty concerns [16,78]. However, insights from the World Economic Forum & PwC report on Industry 4.0-enabled applications for the SDGs underscored the importance of AI technologies in driving Industry 4.0 forward, particularly in areas such as industrial research and development innovation, sustainable infrastructure development, automated and 3D-printed construction, and IoT-enabled infrastructure for efficiency and maintenance (which also aligns with Goal 11, Sustainable Cities and Communities) [79,80]. The study underscores the need for a strategic, fair, and responsible approach to AI integration, emphasizing sustainability, inclusiveness, and fairness. Beyond its innovative solutions, AI mandates a duty to uphold the SDGs' core values. For instance, while AI's potential in alleviating poverty is significant, there's a risk of exacerbating the digital divide if not deployed ethically. The respondents in the final assessment concurred that AI had a predominantly positive impact, with an average score of 7.88 out of 10, aligning with [7] who estimated AI as an enabler for 79% of all SDGs. In essence, this study provides a holistic view of AI's

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potential, recognizing its dual nature across various SDGs and advocating for its judicious use in ensuring a sustainable and inclusive future.

5. Conclusions

From the comprehensive insights gleaned from this research, the aim was to unravel the intricate role of Artificial Intelligence (AI) in shaping the United Nations' Sustainable Development Goals (SDGs). Recognizing AI's expansive impact across a myriad of sectors, it was crucial to dissect its multifarious benefits and inherent challenges. The SDGs, symbolizing global endeavors and hurdles, provided a fitting framework to assess AI's potential contributions. To demystify the intricate dynamics of this relationship, a Delphi approach was employed, drawing upon expert perspectives to elucidate AI's pivotal role in advancing the SDGs. Engaging a panel of distinguished experts, a meticulous evaluation of each SDG was undertaken using a Likert scale, ranging from "Highly Positive Impact" to "Highly Negative Impact". The derived results, delineated via median, mean, standard deviation (SD), and interquartile deviation (IQD) for each goal, offered a refined understanding of AI's footprint. For instance, while Goal 1, aimed at eradicating global poverty, and Goal 14, dedicated to marine conservation, underscored AI's transformative potential, Goal 16, championing peaceful and inclusive societies, presented a more versatile viewpoint, highlighting the diverse ramifications of AI. The consensus among the experts, especially with scores reflecting a strong affirmation of AI's transformative essence across several SDGs, underscores its cardinal role in forging a sustainable trajectory. Notably, AI's adeptness in areas such as urban design, traffic optimization, and disaster response garnered significant median scores, resonating with scholarly contributions that emphasize technology's pivotal role in sustainable urban progression [69]. Through the Delphi method, more insight has been gained into the complex interplay between AI and the SDGs. The insights unearthed underscore the need for a strategic, judicious, and ethical approach to melding AI with the pursuit of the SDGs. In navigating the future, these revelations will serve as guiding beacons, steering the creation of strategies and frameworks that align AI's capabilities with global sustainability aspirations.

5.1. Limitations and Implications for Future Research

In the spirit of scholarly precision, it is crucial to recognize the limitations of this study, which subsequently highlights avenues for further research. The study's exploration of AI's impact on the SDGs might benefit from a more comprehensive and methodical literature assessment. As such, future research ought to delve deeper into the determinants through extensive literature exploration. Additionally, the determinants might have been better organized into three overarching AI categories: technological, ethical, and societal, reflecting the dynamic nature of AI research. Future studies might benefit from utilizing principal component analysis grounded in these categories, providing a more quantitative perspective on AI's contributions to the SDGs. Potential biases, especially those stemming from the selection of experts or the composition of the Delphi panel, could skew the consensus outcomes, casting doubts on the study's validity. To mitigate this, it would be prudent for subsequent studies to establish rigorous criteria that ensure a diverse and unbiased expert selection process. While this research emphasized consensus through the IQD method, other statistical techniques, such as the coefficient of variation (CV), might yield a more definitive consensus. A study juxtaposing the effectiveness of both CV and IQD in a Delphi context, with a focus on AI and the SDGs, would be invaluable in deepening our grasp of Delphi techniques. Moreover, future research should consider converting the determinants pinpointed in this study into indicators, to craft models that predict AI's sway over SDG outcomes. These determinants can also lay the groundwork for a policy framework centered on AI's influence in achieving the SDGs. In practical terms, such a framework would be instrumental for nations striving to align their AI strategies with sustainable development goals. This alignment is paramount to navigating through the complex challenges of our era, with AI poised as a pivotal catalyst for change and progress.

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