# AI AND ESG-DRIVEN GREEN INNOVATION IN THE MIDDLE EAST: OVERCOMING BARRIERS TO SUSTAINABLE TECHNOLOGY ADOPTION

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Purpose: This paper aims to explore how Artificial Intelligence (AI) can enhance synergy between green innovation, sustainable business practices, and key Sustainable Development Goals (SDGs). The study focuses on the Middle East, examining AI's role in accelerating ESG-driven green innovation, identifying barriers to sustainable technology adoption, and proposing strategies to overcome these challenges. Methodology: An exploratory research design is employed to gather data from diverse sources. Thematic analysis is used to identify recurring challenges, enablers, and best practices in the implementation of AI in green innovation. Findings: The study confirms that integrating AI within ESG frameworks significantly boosts the development of green innovations. It also highlights the importance of supportive regulatory environments and targeted training programs in enabling AI technologies to advance sustainability goals effectively. Research Limitations: The study notes a lack of in-depth analysis regarding socio-economic and cultural factors influencing technology adoption in the Middle East, which could limit broader generalizations. Implications: Findings provide valuable insights for policymakers, researchers, and industry leaders aiming to develop effective, context-specific strategies to overcome barriers in sustainable technology adoption and foster AI-driven green innovation.

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# 1 Introduction

For many years, the Middle East has relied on hydrocarbon economies which place oil and gas at the forefront of economic transformation and advancement. The region is now moving toward sustainable development due to global climate requirements together with economic expansion policies and Saudi Arabia's Vision 2030 and the UAE's Net Zero by 2050 strategic initiatives (Islam & Ali, 2024). The business sector recognizes Environmental Social Governance (ESG) standards as essential frameworks which organizations use to establish ethical sustainable social responsibility frameworks during their transformation. AI integration into green innovation represents more than technological progress because it needs detailed policies with sector collaboration as well as cultural changes for socio-economic sustainability. The distinctive socioeconomic together with the geopolitical setting of the area produces unique hurdles as well as possibilities to implement AI-powered sustainable technologies. Effective strategies to speed up ESG-driven green innovation require a clear comprehension of these system dynamics.

#### Rationale

The rationale of this research is mainly lies within a clear understanding how Artificial Intelligence and ESG principles are driving green innovation within the Middle East. It is mainly focusing on overcoming any barriers to adoption of sustainable technology adoption. The paper aims to identify how AI can accurately enhance the synergy between several aspects including green innovation, multiple business practices, and a number of sustainable development goals. The Middle East prioritizes sustainability above all else because of the rising need to combat climate change and global demands to decrease greenhouse gas emissions. AI demonstrates the powerful potential to serve this transition through energy optimization capabilities and supply chain clarity as well as environmental observation functions (Onukwulu, Agho & Eyo-Udo, 2023). It also seeks to identify practical recommendations and policy frameworks for promoting the adoption of AI and green innovation strategies, particularly for SMEs in the region.

# **Research Questions and Hypotheses**

**RQ 1:** How does AI contribute to ESG-driven green innovation in the Middle East? **RQ 2:** What are the key challenges faced in the Middle East region to adopting AIdriven sustainable technologies?

RQ 3: What are the processes of overcoming the raised barriers?

# Hypothesis

**Alternative:** AI integration in ESG initiatives accelerates green innovation by improving resource efficiency and enabling data-driven decision-making.

Null: AI integration into ESG-driven initiatives does not accelerate green innovation by improving resource efficiency and enabling data-driven decision-making

# 2 Literature review & theoretical underpinning

The delivery success of sustainability depends on AI technologies because they increase operational effectiveness and deliver predictive information for enhanced resource allocation systems. The energy sector uses AI-driven technologies to revolutionize the production and storage as well as consumption of energy (Onukwulu, Agho & Eyo-Udo, 2023). The implementation of AI algorithms in smart grids enables real-time demand of supply balance which leads to decreased energy waste while making renewable energy sources more efficient. AI predictive maintenance organizations achieve lower downtime rates and extended infrastructure life expectancies leading to a more functional energy company. Environmental data processing through machine learning models enables individuals to optimize water distribution practices and disease forecasting in crops by assessing soil moisture and meteorological information. Farmers benefit from AI-driven analytics by making data-based choices which decrease environmental consequences with higher agricultural output results.

Organizations now use Environmental Social Governance (ESG) frameworks as their basis to incorporate sustainability through structured operation frameworks within organizational processes and decision systems. The expansion of ESG integration in the Middle East continues under pressure from worldwide investors' increasing interest as documented by Sirisha et al. (2024), along with regional demands for economic transformation and operational resilience. ESG-driven green innovation describes the creation and deployment of technologies alongside products as well as practices which comply with ESG principles for environmental sustainability. Environmental aspects of ESG analysis concentrate on minimizing greenhouse gas emission rates streamlining resource usage and widespread adoption of renewable energy resources. Green innovation in this context encompasses advancements such as carbon capture and storage technologies, the deployment of solar and wind energy, and the creation of energy-efficient infrastructure. Artificial intelligence helps organizations by maximizing energy consumption efficiency and waste management operations while predicting equipment needs in manufacturing processes.

Artificial intelligence tools enable ESG metric monitoring as well as reporting which leads to improved corporate sustainability transparency and accountability (Johansen et al., 2022 p.2). These monitoring instruments assist organizations in measuring their carbon footprints while evaluating social performance and governance systems to maintain corporate- level compliance with worldwide sustainable goals. Multiple research works show that implementing AI-based sustainable technology solutions faces several obstacles specifically within emerging economies. The adoption of sustainable technologies faces crucial barriers from the standpoint of technological readiness and the need for regulatory frameworks as well as socio-cultural acceptance (Pham, Chuah & Feeny, 2021). Economics in the Middle East have relied on hydrocarbon industries since ancient times so they must implement both new technology alongside cultural transformations and legislative changes to become environmentally friendly. Multiple studies demonstrate that Artificial Intelligence possesses extensive potential for sustainable development though modern policies along with better infrastructure are essential to implement it on a widespread scale.

# The Technology Acceptance Model (TAM)

The TAM (Technology Acceptance Model) is one significant theory that is ultimately providing a significant framework for getting a clear understanding how any individuals and also how any organizations are adopting to any new technologies. This is also including any AI and several green technologies. This is specifically relevant to the study topic as it hep to recgnsie the severa factors that may have adirect influence on the adoption of multiple technologies (Park et al. 2022). Additionally it also provide a sound knowledge on perceived usefulness, and any

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external variables such as organizational culture and support. In addition to that, it also help tpo p[redict user adop[tion and allow organization in emnhancing digital readiness.

# **Research Gap**

The research is mainly relies on secondary data and that is why there are few gaps as the secondary data is not porviding the practical experineces of the workers at the workplaces. While it is provding detail insights on AI and the study tiopucbut there is a ack of numerical importantion that may be fufill in the future resarch. While the exsiting rearch also lack a deep insighst on the particular socio economic and cultural factors or aspets that may affect technology adoption within the Middle east. Through addressing these particular gaps, policymakers and reascher will be able in accurately developing targeted strategies in effectively overcoming the barriers.

# 3 Methodology

This study will employ an exploratory research design in this study to gather information from different sources. The missing characteristics of the topic make the exploratory design appropriate because it allows deep investigation into regional behaviour patterns. The research draws data through qualitative approaches that include both literature review studies and analysis of regional case examples. Thematic analysis will identify regular difficulties and success factors and great examples of practice through its application. The research findings will guide strategic policy-making decisions through their contribution to sustainable technology adoption knowledge within emerging economies.

Researchers have collected information from multiple groups which include stakeholders from the public policy sector together with developers who create technology as well as professionals specializing in sustainability. The research technique requires a thorough coding process which reveals common patterns about AI-driven green innovation susceptibilities alongside supportive factors while proposing concrete implementation approaches. The analysis method provides organized comprehension of the main factors which affect sustainable technology adoption by breaking down complicated stories. The researcher can obtain versatile data through thematic analysis from multiple secondary or existing sources. Different types of data need to be analyzed because the subjective elements present uniqueness in the interpretation process. Data will be collected from 2020 till the present time which will make the study more unique. Every interpretation of data will be taken care of to avoid any misinterpretation of taken data. Thereafter, data will be collected from different kind of reliable sources which obtains proper permission to be used.

# 4 **Results (thematic analysis)**

#### Advantages of Artificial Intelligence in Sustainability

The Middle East faces a severe water shortage problem which AI technologies help to resolve effectively. AI systems track water consumption while detecting leaks and estimating usage demand to optimize water management procedures (Jana, 2024 p.160). AI technology deployed at regional desalination plants optimizes energy together with operational performance improvement. AI-affiliated usage mechanisms also allow to identification and sort recyclable materials, enhancing the efficiency of recycling plants and contributing to the circular economy significantly helping with monitoring the environment together with producing models to forecast climate patterns. The analysis of substantial satellite and sensor datasets through AI models enables environmental tracking atmospheric quality recording and climate change predictions (Bianchi & Putro, 2024 p.87). Decision-making authorities gain knowledge through these insights which guide their implementation of protective environmental measures. Artificial Intelligence has the potential to analyze huge datasets in a short period to breakthroughs in factors of sustainability within multiple domains. The successful utilization of AI technologies for ESGdriven green innovation by Middle Eastern countries requires solving existing barriers to achieve their sustainability goals.

# Barriers Causing Obstacles in the Adoption of Sustainable Technology

Various hindrances stand in the way of sustainable technology adoption in the Middle East including regulatory restrictions together with social-emotional obstacles. Several nations face problems with their underdeveloped policies and regulations which fail to create sufficient motivation and regulatory tools to promote sustainable practices (Ogunkan, 2022). The lack of standardized guidelines for AI

integration with ESG initiatives leads to investor and business uncertainties in their efforts. The effective implementation of AI-driven solutions encounters challenges due to insufficient technological capacity which affects organizations across the region because they lack a proper framework and insufficient money and specialized knowledge to use AI technologies effectively. Rural areas face more obstacles in sustainable practices due to their limited access to digital technology because of the extreme digital divide with urban areas.

Academic institutions along with industry and government rarely work together which reduces the speed at which new technology advances. Sustainability adoptions face significant resistance from different cultures that prevent their implementation. The combination of traditional business operations together with the widespread technological mistrust creates obstacles to widespread adoption. AI-driven solution acceptance requires trust-building efforts as well as organizational innovation culture development to surpass these social obstacles (Iyelolu et al. 2024). Firms are also facing issues regarding data privacy and cyber crimes such as companies making AI implementations. Another barrier lies in financing and knowledge spreads.

# Sustainable Development in the Context of the Middle Eastern Context

The special economic structure combined with the environmental situation of the Middle East requires both implementation and technical challenges with sustainable technologies powered by artificial intelligence systems. Old economic and political systems in the region formed through hydrocarbon revenue dependence now need substantial transformation to implement cleaner sustainable practices. The national visions of Saudi Arabia's Vision 2030 and the UAE's Green Agenda 2030 demonstrate a leading political commitment to support sustainable innovation (Islam & Ali, 2024). The initiatives work toward economic diversification while reducing carbon pollution to make Middle Eastern countries leading global examples of sustainable development.

Location elements increase the urgency to adopt sustainable technologies in this region. The region faces three fundamental sustainability issues involving scarce water availability along with harsh environmental temperatures and environmental deterioration which require groundbreaking solutions. Through water resource optimization and precision farming improvements, AI can help resolve

environmental problems. In addition to that, it has identified that the adoption of green innovation that is through AI "artificial intelligence" has also encounters several barriers particularly within its transformation path. The political landscape that is mainly across the area has further demonstrates diverse stabilities mainly due to certain countries have encounter other barriers while implementing any particular reforms. Society also combines a number of perspectives that is associated with the technological adoption as several traditional customs and many doubting attitudes that are specifically towards AI further create obstacles totally against change.

#### 5 Discussion

Both Shot as well as long-term investments that are mainly for sustainable projects and also alongside AI-powered green innovations have been the key source that have prove almost difficult to appropriately secure even a financial backing that is even since numerous economies. It further establishes their overall priorities directly from short-term profits above long-term sustainability goals and aims. Insufficient availability of any green financing may also further hinders the launch as well as deployment of numerous sustainable technology systems (Bianchi & Putro, 2024). In addition to that, from the above result it can be accurately considered that achieving local capacity development and also aquiring sustained creation of policy framework while encouraging sector-wide collaboration has also becomes essential for the primary integration of Artificial Intelligence into multiple sustainable development solutions. The growing dedication of the region that is to sustainability is further reflected through this national movement and it is also while demonstrating a wider acceptance of economic strength and resilience construction.

Artificial Intelligence-driven green innovation has further leads this regional development because it brings sustainable pathways to any developments which are almost consistent with numerous global trends and positions within the Middle East as a significant and even more advanced leader in multiple climate challenge solutions. The result also mentioned that different governments throughout the region steadily increase their investments to digitize operations as they build out their sustainability goals (Islam & Ali, 2024). The Saudi Arabian leadership established Vision 2030 as a strategy which embraces renewable energy together with smart cities and AI applications to make energy divisions sustainable while developing agriculture and water management systems. The UAE utilizes both the Green

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Agenda 2030 and the National AI Strategy to facilitate AI integration across environmental surveillance and waste management along with energy optimization because they seek to use technology for sustainable development.

#### 6 Conclusions

Websites show that artificial intelligence speeds up ESG-driven green innovation through better decision-making methods and improved energy efficiency and environmental problem solutions. Still there exist obstacles including incomplete policies and cultural opposition and unprepared technology which must receive attention. The research verifies that AI integration within ESG initiatives speeds up the development of green innovative approaches. The study proves that proper regulation and training programs enable AI technologies to promote sustainable technological advancements within the area. The study uses qualitative methods combined with a case study which restricts the wide applicability of its results.

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