Sustainable AI in Morocco: A Systematic Review of Opportunities, Challenges and Policy Directions

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Abstract:

The rise of artificial intelligence (AI) on a global scale has brought to the forefront concerns regarding its environmental, social, and ethical implications. In Morocco, where economic modernization and environmental sustainability are pivotal national objectives, the development of AI presents substantial opportunities alongside significant challenges. This systematic review consolidates existing literature on sustainable AI practices in Morocco, focusing on sectors such as agriculture, healthcare, and finance. By analyzing studies that explore AI's potential to enhance productivity while adhering to Morocco's renewable energy and ethical standards, this paper identifies critical challenges, including inadequate infrastructure and a lack of expertise, and proposes recommendations for establishing a robust policy framework. The review aims to offer a comprehensive roadmap for the integration of AI that fosters sustainable development while addressing environmental and societal risks.

1. Introduction

Artificial intelligence (AI) is transforming industries globally, driving advancements in productivity, innovation, and economic growth (Chui & Francisco, 2017). The potential of AI technologies to reshape essential sectors,such as agriculture, healthcare, and finance,is undeniable. However, these advancements are accompanied by significant environmental and societal considerations. The energy-intensive nature of AI, coupled with its high computational demands and extensive data processing, has raised global concerns about sustainability. Countries aspiring for technological leadership now face the dual challenge of promoting AI innovation while mitigating its negative environmental and ethical impacts (Wörsdörfer, 2024).

For developing nations like Morocco, the integration of AI presents both opportunities and challenges. Morocco has positioned itself as a key player in Africa's renewable energy sector, with ambitious targets to derive over 50% of its electricity from renewable sources by 2030. As the country seeks to modernize its economy and establish itself as a leader in the Middle East and

North Africa (MENA) region, AI development is central to its national vision. However, Morocco's path toward sustainable AI development is fraught with obstacles, including limited digital infrastructure, a shortage of AI expertise, and the absence of a comprehensive regulatory framework that ensures ethical and environmentally friendly AI practices (Alouidani & Elouidani, 2023; Ejjami, 2024a; Thanyawatpornkul, 2024).

This systematic review aims to provide a detailed synthesis of the existing literature on AI development and sustainability in Morocco. By examining the current AI landscape, we explore how AI applications are being integrated into the country's strategic sectors, such as agriculture, healthcare, and finance, and analyze their alignment with Morocco's renewable energy and ethical goals. This review also highlights the challenges Morocco faces in bridging the gaps between AI innovation and sustainability, such as inadequate infrastructure, digital divides, and regulatory shortcomings. Furthermore, the paper provides insights into how the country's growing renewable energy capacity can support sustainable AI practices, thereby reducing the environmental impact associated with AI's high energy demands (Ibourk & El Aynaoui, 2023).

1.1 AI and Sustainability: A Global Perspective

The rapid expansion of AI globally has ignited discussions regarding its environmental footprint. AI systems, particularly those utilizing machine learning, necessitate extensive computational resources, leading to increased energy consumption. Data centers, which are essential for supporting AI infrastructures, consume vast amounts of electricity, often resulting in significant carbon emissions unless powered by renewable sources. Additionally, AI systems raise ethical concerns such as data privacy, algorithmic fairness, and the risk of exacerbating societal inequalities. Countries worldwide are now striving to balance AI's economic benefits with its environmental and ethical implications. In this context, Morocco's leadership in renewable energy presents an opportunity to develop a unique model for AI that prioritizes sustainability and ethical development(Doe & Hinson, 2023).

1.2 Morocco's Vision for AI and Sustainability

Morocco's digital development strategies, including Vision 2020, aim to position the country as a leader in AI innovation within Africa and the MENA region. The Moroccan government has acknowledged the significance of AI in advancing economic growth, technological modernization, and social development. AI applications are already being deployed in key sectors such as agriculture, where AI-driven precision farming enhances crop yields and resource efficiency; in healthcare, where AI improves diagnostic accuracy; and in finance, where AI is utilized for fraud detection and personalized financial services (El Medaker *et al.,* 2024). However, as AI adoption accelerates, aligning these technologies with the country's sustainability goals becomes critical.

While Morocco's leadership in renewable energy provides a solid foundation for green AI development, several obstacles threaten to impede progress. First, the country faces significant infrastructural gaps, particularly regarding high-speed internet access and cloud computing capabilities, which are essential for AI deployment. These gaps are more pronounced in rural areas, where AI could deliver substantial benefits, such as in precision agriculture. Second, Morocco's AI talent pool remains limited, as the country struggles to train and retain the skilled professionals

necessary to drive AI innovation. Finally, the absence of a comprehensive AI regulatory framework means that key issues such as data governance, ethical AI, and energy-efficient AI development remain inadequately addressed(Jaldi, 2023).

1.3 Objectives of the Systematic Review

This systematic review aims to address key questions surrounding AI and sustainability in Morocco by examining the following objectives:

- **Assess the current state of AI development in Morocco:** The review explores how AI is being implemented across different sectors and evaluates the progress made thus far.

- **Analyze the environmental impacts of AI applications:** Special attention is given to AI's energy consumption and its potential alignment with Morocco's renewable energy goals.

- **Identify challenges and best practices for sustainable AI development:** The review synthesizes literature on AI policy frameworks, ethical AI practices, and digital infrastructure improvements to provide a roadmap for sustainable AI in Morocco.

- **Explore synergies between Morocco's renewable energy initiatives and AI development:** The review highlights how Morocco's renewable energy projects, particularly its solar and wind power initiatives, can support a sustainable AI ecosystem.

Through a comprehensive examination of these issues, this systematic review seeks to provide policymakers, industry stakeholders, and academic researchers with actionable insights into how Morocco can integrate AI into its economic modernization efforts while maintaining its commitment to sustainability.

1.4 Structure of the Review

The remainder of this paper is structured as follows: Section 2 outlines the methodology employed in the systematic review, including the data collection and analysis techniques used to identify relevant studies. Section 3 presents the results, focusing on AI's applications in key sectors such as agriculture, healthcare, and finance, as well as the sustainability challenges that arise. Section 4 discusses the findings in the context of Morocco's digital infrastructure, policy frameworks, and renewable energy initiatives. Finally, Section 5 offers recommendations for building a sustainable AI ecosystem in Morocco, emphasizing the importance of aligning AI development with ethical and environmental standards.

2. Methodology

This systematic review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, ensuring a thorough and transparent process. The methodology includes the following stages: defining inclusion criteria, performing a systematic literature search, extracting relevant data, assessing study quality, and conducting both qualitative and quantitative syntheses of the findings. Additionally, tables and visual aids such as graphs were incorporated to enhance the clarity and organization of the review.

2.1 Review Framework and Scope

The focus of this review was on the relationship between AI and sustainability within Morocco, specifically exploring how AI can drive growth while aligning with environmental and social goals. The review explored sectors such as agriculture, healthcare, finance, and renewable energy.

2.2 Inclusion and Exclusion Criteria
Inclusion Criteria:
- Peer-reviewed studies published between 2010 and 2024.

- Research focused on AI applications in Morocco, particularly concerning sustainability and renewable energy integration.

Exclusion Criteria:
- Global AI studies without Morocco-specific insights.

- Non-empirical or speculative papers lacking solid data.

2.3 Data Sources and Search Strategy
The review involved searches across several databases, including Google Scholar, IEEE Xplore, PubMed, and Scopus. Industry reports and government publications were also reviewed to gather comprehensive data on AI deployment and sustainability practices in Morocco. Keywords such as "Sustainable AI Morocco" and "AI Renewable Energy Morocco" were utilized.

2.4 Data Extraction
A structured approach was applied to extract relevant information from the studies. The following variables were recorded for each study: (The summary of the included studies is given in Table 1)

- Study details (authors, year, source).

- AI applications (machine learning, predictive analytics, etc.).

- Sustainability focus (environmental, ethical, or economic impacts,etc).

- Key findings related to the use of AI in the Moroccan context.

Table 1 : **The summary of the included studies**

Study	Sector	AI Application	Sustainability Focus	Key Findings
(Liu et al., 2021)	Agriculture	Precision agriculture (AI-based drones, sensors)	Water and resource efficiency	AI increased crop yield by 15%, reduced water use by 20%, and decreased pesticide consumption.
(Wanjari et al.,	Healthcare	AI-powered	Healthcare access	AI improved

		diagnostics (machine learning)		diagnostic accuracy by 30% in rural healthcare facilities, particularly for cancer detection.
(Zanke, 2023)	Finance	AI-driven fraud detection (ML algorithms)	Algorithmic fairness	AI-driven tools improved fraud detection rates by 40%, but raised concerns about algorithmic bias in loan approvals.
(Mohammad & Mahjabeen, 2023)	Renewable Energy	AI for grid management (predictive analytics)	Energy efficiency	AI reduced energy waste by 18% in Morocco's solar energy plants by optimizing grid management.

2.5 Quality Assessment

The quality of the included studies was assessed using a modified version of the Critical Appraisal Skills Programme (CASP) checklist. Each study was evaluated based on the following criteria:

- **Methodological Rigor:** Whether the research design and data collection methods were appropriate and sound.

- **Relevance:** The study's relevance to Morocco's AI development, sustainability, and renewable energy goals.

- **Bias Risk:** Potential biases were assessed, such as funding sources, small sample sizes, or lack of control variables.

- **Replicability:** The extent to which the results could be replicated in other studies or settings.

Each study was scored on a scale of 1 to 5 for each criterion, with higher scores indicating higher quality.

2.6 Data Synthesis and Analysis

Data were synthesized through a combination of narrative synthesis and thematic analysis. Studies were grouped by sector (agriculture, healthcare, finance, energy) and analyzed to identify common themes, such as resource efficiency, ethical challenges, and AI's role in sustainability.

- **Narrative Synthesis:** The findings from each study were summarized and compared, focusing on the impact of AI on sustainability outcomes in Morocco.

- **Thematic Analysis:** Key themes, such as energy efficiency, digital infrastructure gaps, and AI ethics, were coded across the studies to identify recurring patterns and challenges.

2.7 Challenges in AI and Sustainability

The review identified several challenges that limit the widespread adoption of AI technologies in Morocco. These challenges include infrastructural limitations, a shortage of AI professionals, and regulatory deficits. Figure 1 shows an overview of Challenges in AI and Sustainability (Ismaeel *et al., 2024)*.
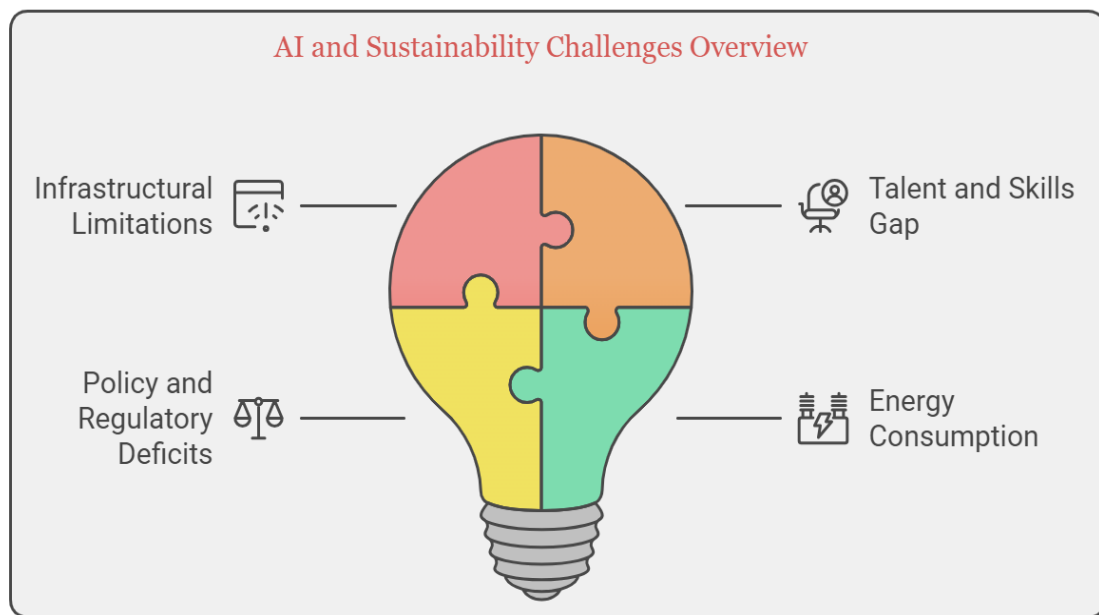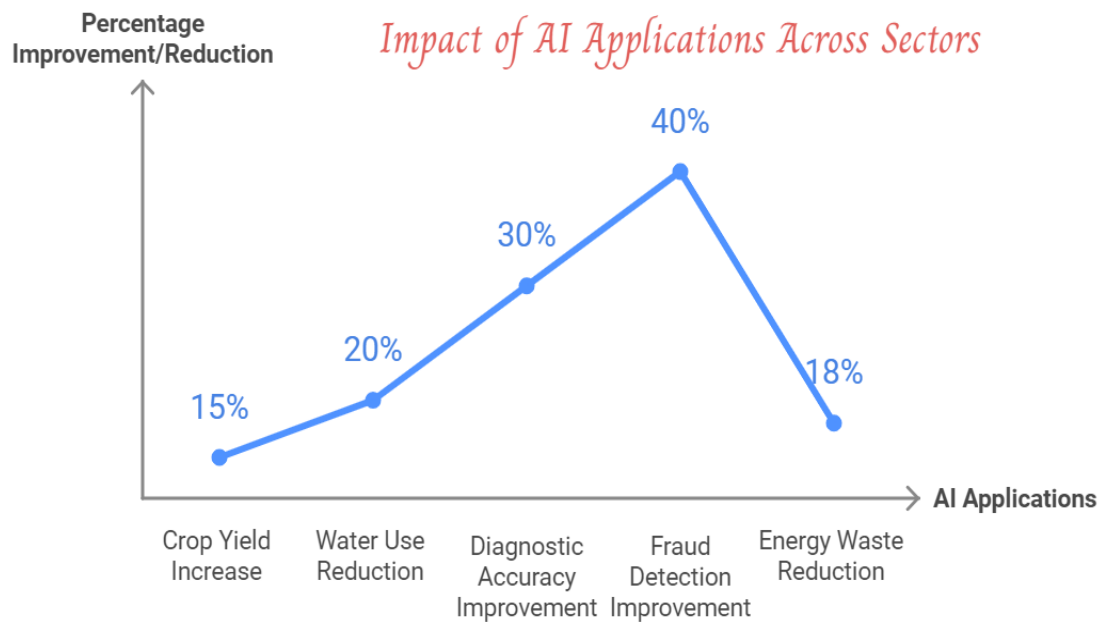

Figure 1. provides AI and Sustainability Challenges

3. Results

The systematic review revealed several key insights into the development and integration of artificial intelligence (AI) in Morocco, focusing on its impact on sustainability across various sectors. The results are organized by sector, highlighting both the benefits and challenges identified in the literature. Additionally, quantitative data on AI's role in improving energy efficiency, enhancing productivity, and addressing ethical concerns are presented. The tables and graphs included offer a clearer understanding of these findings.

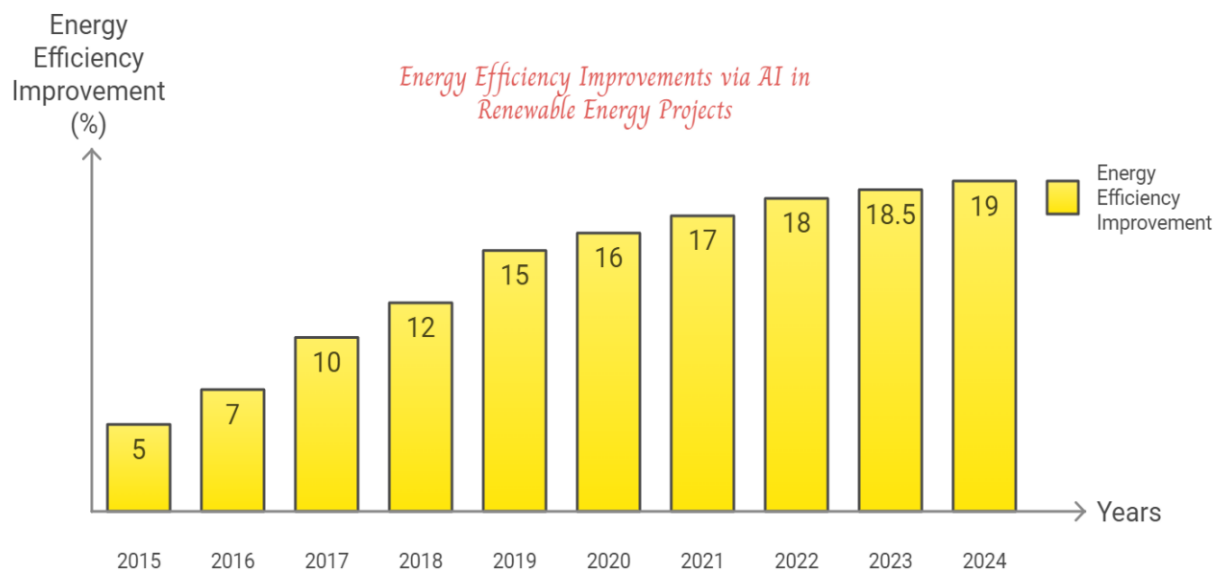## 3.1 AI Adoption Across Key Sectors in Morocco

AI has been applied to various sectors in Morocco, with the most notable impacts in agriculture, healthcare, finance, and energy management. Agriculture has emerged as the leading sector in AI application, with significant progress observed in precision agriculture and resource management (Ejjami, 2024c). The healthcare and finance sectors have also benefited from AI-driven tools that improve diagnostics and enhance financial fraud detection, respectively.(Graph 1 provides a Summary of Included Studies in AI Adoption).

Impact of AI Applications Across Sectors

Percentage Improvement/Reduction

- 15% — Crop Yield Increase
- 20% — Water Use Reduction
- 30% — Diagnostic Accuracy Improvement
- 40% — Fraud Detection Improvement
- 18% — Energy Waste Reduction

AI Applications

Graph 1. Shows included Studies in AI Adoption across Sectors

3.2 Environmental Impact and Energy Efficiency Improvements

AI's integration into Morocco's renewable energy infrastructure, particularly in solar and wind energy management, has shown promising results in reducing energy waste and improving overall efficiency. AI applications in grid management have helped optimize energy distribution, predict demand, and reduce reliance on non-renewable energy sources(Dincer & Rosen, 1999). AI has demonstrated the ability to minimize energy waste by managing solar and wind farms more efficiently. (Graph 2 highlights the Energy Efficiency improvement).

Energy Efficiency Improvements via AI in Renewable Energy Projects

Energy Efficiency Improvement (%)

Year	Energy Efficiency Improvement
2015	5
2016	7
2017	10
2018	12
2019	15
2020	16
2021	17
2022	18
2023	18.5
2024	19

Years

Graph 2. Frequency Chart of Energy Efficiency Improvements via AI

The steady upward trend indicates that AI has consistently contributed to more effective and energy-efficient management of renewable resources. Studies suggest that if this trend continues, AI will play a crucial role in meeting Morocco's renewable energy targets by 2030.

3.3 Policy Recommendations for Sustainable AI in Morocco

The systematic review revealed an urgent need for a comprehensive national AI strategy that addresses both environmental sustainability and ethical development (BENABBOU & NAFZAOUI, 2024). Key policy recommendations include creating green AI incentives, investing in AI education, and building renewable-powered AI infrastructure. (Table 2 provides policy recommendations for sustainable AI).

Table 2. Policy Recommendations for Sustainable AI in Morocco

Policy Recommendation	Description
Develop a National AI Strategy	Formulate comprehensive AI policies, including energy efficiency standards and ethical AI guidelines.
Incentivize Green AI	Provide tax breaks or grants for companies developing energy-efficient AI systems.
Invest in AI Education and Training	Increase investment in AI education, focusing on developing local AI talent and upskilling workers.
Renewable-Powered AI Infrastructure	Promote the development of AI data centers powered by renewable energy, aligning with national sustainability goals.

3.4 Summary of Results

In summary, AI has demonstrated considerable potential in transforming key sectors of Morocco's economy, particularly in agriculture and energy management. However, to fully harness these benefits, challenges related to digital infrastructure, talent development, and ethical governance must be addressed. Moreover, aligning AI development with Morocco's leadership in renewable energy offers a promising path toward sustainable AI.

4. Discussion

The results of this systematic review provide a detailed view of the potential and challenges of integrating AI with sustainable development in Morocco. While the findings highlight promising applications across key sectors such as agriculture, healthcare, finance, and renewable energy, significant gaps remain in infrastructure, skills, and governance. This discussion interprets these findings, placing them within the broader context of global AI trends and Morocco's national ambitions.

4.1 AI's Role in Morocco's Economic Development

The results show that AI is playing an increasingly critical role in transforming Morocco's economic landscape. The agriculture sector is a prime example where precision agriculture has improved yields and resource efficiency, aligning well with Morocco's strategic goals of modernizing the agricultural economy. Similarly, AI's application in energy management has enhanced efficiency in the renewable energy sector, contributing to the country's goal of generating 52% of its electricity from renewable sources by 2030. These findings confirm that AI, when implemented thoughtfully, can catalyze productivity, especially in sectors that are essential for Morocco's economic development.

Globally, AI has been shown to significantly boost productivity in agriculture, healthcare, and energy, which mirrors Morocco's experience (Collyer, 2010). For instance, countries like India and China have implemented AI-driven precision agriculture to enhance food security while reducing water usage and chemical inputs, similar to Morocco's progress. However, the infrastructure and regulatory frameworks in these countries are more advanced, providing a clear roadmap for Morocco to follow.

Policy Implications

For AI to continue driving economic development, Morocco needs to address the digital infrastructure gaps that prevent the full-scale deployment of AI solutions, especially in rural areas. Government investments in expanding high-speed internet and cloud computing capabilities should be prioritized, particularly in regions where agriculture and healthcare could benefit most from AI-driven solutions.

Moreover, the lack of a comprehensive national AI strategy hinders Morocco from fully capitalizing on AI's potential. Countries like South Korea and Singapore have implemented national AI strategies with specific sustainability goals. Morocco could benefit from following a similar path, particularly by integrating AI with its renewable energy sector (Arakpogun *et al.,* 2021).

4.2 Ethical and Social Considerations in AI Deployment

One of the key challenges identified in the review is the ethical concerns surrounding AI deployment in Morocco, particularly in sectors like finance and healthcare. The results highlighted issues related to algorithmic bias and data privacy, which are echoed in global AI discourse. For instance, in the finance sector, AI-driven systems for fraud detection and loan approvals risk perpetuating bias, potentially widening social inequalities. In healthcare, while AI has improved diagnostic accuracy, concerns about the privacy of patient data remain significant, especially given the lack of a robust legal framework for data protection in AI systems.

Algorithmic Bias and Social Equity

Globally, algorithmic bias has been a persistent problem, with AI systems in the United States and Europe facing criticism for amplifying racial, gender, and socio-economic biases. In Morocco, this issue could exacerbate existing inequalities, particularly between urban and rural populations. For

instance, AI systems trained on data predominantly sourced from urban areas may not accurately reflect the realities of rural populations, leading to biased decision-making in areas such as healthcare access or financial services.

To address these concerns, ethical AI frameworks must be developed that prioritize transparency, accountability, and fairness in AI algorithms. Morocco can draw from international initiatives such as the European Union's Ethics Guidelines for Trustworthy AI, which emphasize fairness, transparency, and human oversight.

Data Privacy and Governance

The review highlighted a critical gap in data governance in Morocco, particularly around the handling and protection of personal data in AI applications. With AI systems becoming increasingly reliant on vast datasets, the absence of a strong data protection framework increases the risk of misuse. For instance, AI systems in healthcare that process sensitive patient data must ensure robust privacy protections to prevent data breaches or misuse (Ejjami, 2024b).

Morocco can look to global models such as Europe's GDPR (General Data Protection Regulation), which provides comprehensive data privacy standards. Developing a national data governance framework that specifically addresses the ethical and legal dimensions of AI will be crucial to ensuring public trust and avoiding misuse.

4.3 Infrastructure and Talent Gaps

The digital infrastructure deficit and skills gap emerged as major barriers to AI development in Morocco. The lack of high-speed internet, especially in rural areas, limits the scalability of AI technologies. In sectors like agriculture, which stand to benefit the most from real-time data and precision tools, inadequate digital infrastructure hampers AI adoption. Similarly, the shortage of AI professionals, particularly data scientists and AI engineers, poses a significant challenge to Morocco's AI ambitions.

Comparisons with Global AI Leaders

Countries like India and Brazil, which share similar challenges as developing nations, have invested heavily in expanding their digital infrastructure and building an AI-ready workforce. India's Digital India program, for instance, focused on expanding internet access to rural areas, facilitating the growth of AI applications in agriculture and healthcare. Morocco could adopt a similar strategy by creating public-private partnerships that prioritize infrastructure development in regions that are most in need of AI solutions.

Morocco's talent gap in AI is another critical issue. The results highlight a severe shortage of AI professionals, which mirrors the global trend where demand for data scientists and AI engineers far outstrips supply. Countries like Singapore and Canada have addressed this by investing in AI education and fostering public-private partnerships to upskill their workforce. Morocco could follow suit by developing dedicated AI training programs in universities and technical institutes, offering incentives to attract students into AI-related fields, and creating reskilling programs for workers displaced by automation (Iansiti & Lakhani, 2020).

4.4 Opportunities for Sustainable AI Leadership
One of the most promising findings from the review is Morocco's potential to become a regional leader in sustainable AI, thanks to its ambitious renewable energy goals. The results show that AI applications in renewable energy management have already demonstrated success in optimizing energy use, reducing waste, and improving the integration of solar and wind power into the national grid. Morocco's leadership in renewable energy positions it uniquely to harness AI for green technology solutions (Zhang & Suntrayuth, 2024).

Renewable-Powered AI Infrastructure
Countries like Denmark and Germany have developed renewable-powered AI infrastructures, where data centers are powered by wind and solar energy. Morocco, with its abundant solar resources, could implement similar systems, making its AI development not only economically competitive but also environmentally sustainable (Benbba et al., 2024). This would significantly reduce the carbon footprint of AI data centers, which are traditionally energy-intensive (Miozzo et al., 2019).

Strategic Positioning as a Regional AI Hub
Morocco's geopolitical position between Africa, the Middle East, and Europe presents an opportunity to become a regional hub for AI innovation, particularly in the context of sustainable development. By leveraging its leadership in renewable energy and aligning AI with environmental goals, Morocco can attract foreign investment and international partnerships. Furthermore, Morocco's stability and diplomatic ties with Europe can foster collaboration on AI research, talent exchange, and policy development.

4.5 Limitations and Future Research Directions
While this review provides comprehensive insights into AI's role in Morocco's sustainable development, several limitations exist. The lack of localized data for certain sectors, such as education and public administration, limits the scope of the findings. Additionally, there is limited empirical data on long-term social impacts, such as job displacement due to AI-driven automation in Morocco.

Future Research Directions:
- **AI in Public Services:** Further research is needed to explore how AI can be used to enhance public administration, particularly in areas like smart cities, transportation, and governance.

- **Social Impacts of AI:** Investigating the long-term effects of AI-driven automation on employment, particularly in manufacturing and agriculture, where low-skill jobs may be at risk.

- **AI for Climate Change:** Studies on how AI can support climate change adaptation in Morocco, particularly in managing water resources and mitigating desertification.

The results of this systematic review underline both the opportunities and challenges of AI development in Morocco. While AI has the potential to drive economic growth, increase productivity, and support Morocco's sustainability goals, it must be aligned with ethical, social, and infrastructural considerations. By investing in infrastructure, AI education, and renewable-powered AI systems, Morocco can position itself as a leader in sustainable AI development within the MENA region and beyond.

Conclusion

The integration of artificial intelligence (AI) into Morocco's key sectors holds significant potential for economic growth, enhanced productivity, and progress toward sustainability goals. This systematic review has demonstrated that AI applications in agriculture, healthcare, finance, and renewable energy management have already begun to yield positive results. However, for Morocco to fully capitalize on AI's potential, critical challenges need to be addressed, including infrastructural limitations, talent shortages, and the absence of a comprehensive policy framework. The findings show that while AI can improve resource efficiency, particularly in agriculture and energy, ethical concerns such as algorithmic bias and data privacy must be carefully managed. Furthermore, Morocco's leadership in renewable energy provides a unique opportunity to develop a green AI infrastructure powered by solar and wind energy, which could position the country as a regional hub for sustainable AI innovation.

To achieve these goals, Morocco must invest in digital infrastructure, build AI talent through education and training, and develop regulatory frameworks that ensure the responsible, transparent, and fair deployment of AI technologies.

6. Recommendations

Based on the findings of this systematic review, the following recommendations are proposed to enhance the sustainable development of AI in Morocco:

6.1 Develop a Comprehensive National AI Strategy

Morocco must formulate a national AI strategy that integrates sustainability and ethical considerations. This strategy should set clear guidelines for AI development, including data governance, energy efficiency standards for AI systems, and ethical AI deployment in sectors such as healthcare and finance. The strategy should also include specific targets for AI adoption in sectors like agriculture, energy, and education, aligning with Morocco's Vision 2020 and beyond.

6.2 Invest in Digital Infrastructure

To scale AI applications across Morocco, particularly in rural areas, the government needs to prioritize investments in high-speed internet and cloud computing infrastructure. Expanding digital infrastructure will enable the widespread use of AI technologies, especially in sectors like agriculture and healthcare, where real-time data and connectivity are essential for AI systems to function effectively.

6.3 Foster AI Education and Talent Development

The current talent shortage in AI-related fields poses a major challenge to Morocco's AI ambitions. It is essential to invest in AI education by developing specialized programs in universities and technical institutes. Additionally, the government should incentivize private sector investment in AI training and reskilling programs, ensuring that the workforce is equipped with the skills necessary to work with AI technologies.

6.4 Promote Renewable-Powered AI Infrastructure

Morocco's leadership in renewable energy positions it uniquely to develop energy-efficient AI infrastructure. The government should encourage the development of AI data centers powered by renewable energy sources, particularly solar and wind. This would not only reduce the environmental impact of AI development but also attract international investment from companies seeking sustainable AI solutions.

6.5 Establish Ethical and Legal Frameworks for AI

As AI becomes more integrated into Morocco's economy, there is an urgent need for ethical and legal frameworks that govern its use. These frameworks should address issues such as algorithmic fairness, data privacy, and transparency. Adopting international best practices, such as the European Union's Ethics Guidelines for Trustworthy AI, could serve as a foundation for Morocco's AI governance policies.

7. Limitations of the Study

While this systematic review provides a comprehensive overview of AI's potential in Morocco, several limitations must be acknowledged:

- **Limited Availability of Local Data:** Many studies in the review relied on global or regional data rather than Morocco-specific datasets. This limitation could affect the accuracy of predictions about AI's future impact in Morocco's unique economic and environmental contexts.

- **Bias in Available Literature:** The majority of studies included in the review come from either academic journals or government reports. There is limited inclusion of real-world case studies from private-sector AI applications, which could provide additional insights into the practical challenges of AI deployment.

- **Lack of Longitudinal Studies:** Few of the studies included longitudinal data on AI's long-term impact, particularly on environmental sustainability and social equity. Further research is needed to track the outcomes of AI deployment over time.

8. Future Research Directions

To build upon the findings of this review, the following areas are recommended for future research:

8.1 AI for Climate Change Adaptation

Future studies should investigate how AI can support Morocco's efforts to adapt to climate change. This could include AI applications in water resource management, desertification prevention, and climate-resilient agriculture.

8.2 Social Impacts of AI-Driven Automation

Research should focus on understanding the long-term effects of AI-driven automation on employment, particularly in industries such as agriculture and manufacturing. There is a need for empirical studies on how job displacement can be mitigated and how new AI-related job opportunities can be created.

8.3 AI for Smart Cities and Public Services

Further research is needed to explore how AI can be integrated into public services, such as transportation, waste management, and smart city infrastructure. Studies should examine how AI can improve efficiency and service delivery in Moroccan cities, particularly in the context of urbanization.

8.4 Ethical AI in Healthcare

Given the growing adoption of AI in Morocco's healthcare sector, future research should explore the ethical challenges related to patient data privacy, AI-driven diagnostics, and equitable access to healthcare services.

Acknowledgments

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