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AI-driven project optimization: A strategic framework for accelerating sustainable development outcomes

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Abstract

This paper explores the transformative role of artificial intelligence (AI) in optimizing projects to accelerate progress toward Sustainable Development Goals (SDGs). It presents a strategic framework for integrating AI into project design, monitoring, and implementation, emphasizing its potential to enhance efficiency, scalability, and impact across diverse sectors. The discussion highlights key AI technologies, such as machine learning and predictive analytics, and their alignment with specific SDGs, including clean energy, sustainable cities, and climate action. Addressing challenges such as ethical considerations, data security, and the digital divide, the paper underscores the importance of policy support, cross-sector collaboration, and grassroots engagement. Finally, actionable recommendations are proposed to enable stakeholders to adopt and scale AI-driven optimization responsibly. By leveraging AI strategically, stakeholders can foster innovation and inclusivity, accelerating sustainable development outcomes globally.

Keywords: Artificial Intelligence; Sustainable Development Goals; Project Optimization; Data-Driven Decision-Making; Ethical AI

1. Introduction

The Sustainable Development Goals (SDGs), introduced by the United Nations in 2015, represent a global blueprint for addressing pressing challenges such as poverty, inequality, climate change, and environmental degradation (Georgeson & Maslin, 2018). These 17 goals, with their interconnected targets, provide a framework for nations, organizations, and individuals to work collaboratively toward a more equitable and sustainable future by 2030 (Dalampira & Nastis, 2020). However, achieving these ambitious goals requires transformative strategies that leverage innovation, efficiency, and cross-sectoral collaboration. Traditional approaches, while valuable, often fall short of addressing the complexities and interdependencies inherent in sustainable development (Stott & Murphy, 2020).

Emerging technologies, particularly artificial intelligence (AI), offer unprecedented opportunities to accelerate progress toward these goals (Ahmad et al., 2021). With its ability to process vast amounts of data, identify patterns, and provide predictive insights, AI is increasingly recognized as a critical enabler in optimizing resource allocation, decision-making, and impact assessment. Integrating AI into SDG-oriented projects is not merely an enhancement but a necessity for maximizing efficiency and ensuring that initiatives are both scalable and sustainable (Dwivedi et al., 2021).

AI has rapidly evolved from a theoretical discipline into a transformative force across diverse industries, from healthcare to transportation and energy. In the context of sustainable development, AI's capabilities align seamlessly with the need for strategic optimization. For example, in renewable energy management, AI algorithms are being used to predict energy demand, optimize grid operations, and enhance the efficiency of solar and wind power generation

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(Yigitcanlar, Mehmood, & Corchado, 2021). Similarly, in agriculture, AI-driven tools monitor crop health, predict weather patterns, and optimize irrigation, thereby reducing waste and increasing yield. Moreover, AI has enhanced urban sustainability through smart city initiatives. By analyzing traffic patterns, air quality, and energy consumption, AI systems enable the development of solutions that reduce congestion, lower emissions, and improve the quality of urban life. These applications illustrate AI's potential to address complex, multi-dimensional challenges that traditional methods often fail to resolve effectively (Javaid, Haleem, Khan, & Suman, 2023).

AI is also pivotal in financial and policy planning for sustainable development. Machine learning models can forecast economic trends, assess the impact of policy changes, and identify areas requiring urgent intervention. Such capabilities ensure that limited resources are allocated where they will generate the greatest impact. The growing adoption of AI in these domains underscores its transformative potential to reshape how sustainability objectives are pursued and achieved (Mhlanga, 2021).

This paper explores the strategic integration of AI into project optimization frameworks designed to advance sustainable development outcomes. While much attention has been given to the individual applications of AI, there is a need for a cohesive approach that combines these technologies into comprehensive systems capable of driving holistic, long-term progress. The paper will focus on theoretical insights and propose a conceptual framework for AI-driven project optimization. Key elements include leveraging AI for data-driven decision-making, real-time monitoring, and impact assessment. By emphasizing the interplay between technological innovation and sustainability objectives, the framework seeks to guide stakeholders in aligning AI adoption with the principles of sustainable development. In addition to identifying opportunities, the paper will address critical challenges associated with AI implementation, including ethical concerns, data privacy issues, and the risk of exacerbating the digital divide. The objective is to provide a balanced perspective highlighting AI's transformative potential and the considerations necessary to ensure its responsible and equitable use.

Ultimately, the paper seeks to contribute to the growing discourse on how emerging technologies can be harnessed to create sustainable, inclusive, and resilient systems. It underscores the importance of viewing AI as a tool and a strategic ally in the global quest to achieve the SDGs. The paper aspires to empower policymakers, industry leaders, and development practitioners to embrace AI-driven innovation as a cornerstone of sustainable development by presenting actionable recommendations and forward-looking insights.

2. The Role of AI in Sustainable Development

2.1. Key AI Technologies Relevant to Project Optimization

Artificial intelligence (AI) encompasses a range of technologies designed to simulate human intelligence and automate complex decision-making processes. Among the most impactful AI tools in sustainable development are machine learning (ML), predictive analytics, natural language processing (NLP), and computer vision (Duan, Edwards, & Dwivedi, 2019). These technologies collectively provide the capacity to process large volumes of data, uncover patterns, and offer actionable insights, making them indispensable for optimizing sustainability-focused projects (Jarrahi, 2018).

Machine learning, a subset of AI, enables systems to improve their performance over time by learning from data. This capability is vital for resource-intensive domains such as agriculture, where ML algorithms can predict optimal planting times, detect crop diseases early, and forecast yields (Meshram, Patil, Meshram, Hanchate, & Ramkteke, 2021). Predictive analytics, which combines statistical modeling with AI, extends these benefits by forecasting future trends based on historical data. In the context of sustainable development, predictive analytics has been instrumental in urban planning, allowing cities to anticipate population growth, traffic congestion, and energy demands (Ahmad, Madonski, Zhang, Huang, & Mujeeb, 2022).

Natural language processing has found utility in policy formulation and stakeholder engagement. By analyzing textual data from diverse sources, NLP tools can identify emerging sustainability challenges, monitor public sentiment, and evaluate the effectiveness of existing policies. Similarly, computer vision, which involves visual data interpretation, has proven invaluable for environmental monitoring. For instance, AI-powered drones with computer vision can detect deforestation, monitor biodiversity, and assess damage from natural disasters. These capabilities enable project managers to respond swiftly and effectively to dynamic challenges (Saheb, Dehghani, & Saheb, 2022). Integrating these AI technologies into project optimization processes ensures that resources are used efficiently, risks are minimized, and desired outcomes are achieved. Furthermore, by automating repetitive tasks, AI frees human experts to focus on strategic decision-making, thereby enhancing the overall effectiveness of sustainability initiatives.

2.2. Alignment of AI Applications with Specific SDGs

AI's transformative potential is particularly evident in its alignment with specific Sustainable Development Goals (SDGs). By addressing the unique requirements of various goals, AI technologies act as accelerators for sustainable progress across sectors. Below are some examples of AI applications aligned with key SDGs:

2.2.1. SDG 7: Affordable and Clean Energy

AI is driving significant advancements in clean energy generation and distribution. Machine learning algorithms optimize the performance of renewable energy sources such as solar panels and wind turbines by analyzing weather patterns and adjusting operational parameters in real time. Predictive analytics ensures that energy supply meets demand, reducing waste and enhancing grid stability. Moreover, AI-enabled microgrid management systems empower remote and underserved communities to access reliable and sustainable energy, directly contributing to the achievement of SDG 7 (W. Li, 2019).

2.2.2. SDG 11: Sustainable Cities and Communities

Rapid urbanization has intensified the need for sustainable urban planning, and AI offers a robust solution. Smart city technologies, powered by AI, are transforming urban environments by improving transportation systems, waste management, and energy efficiency. For example, AI-driven traffic management systems reduce congestion and lower emissions by optimizing real-time traffic flow. Additionally, computer vision aids in monitoring air quality, while NLP tools facilitate community engagement by analyzing feedback on urban initiatives. These applications align closely with SDG 11's objective of creating inclusive, safe, and sustainable cities (Kasinathan et al., 2022).

2.2.3. SDG 13: Climate Action

Combatting climate change requires timely and informed actions, and AI provides critical support in this area. Climate models enhanced by AI offer precise predictions of weather patterns, helping governments and organizations prepare for extreme weather events. AI is also being used to optimize carbon capture and storage technologies, assess the impact of climate policies, and track greenhouse gas emissions globally. These efforts are essential for achieving SDG 13, which emphasizes urgent measures to combat climate change and its impacts (Cowls, Tsamados, Taddeo, & Floridi, 2023).

2.2.4. SDG 2: Zero Hunger

AI technologies are pivotal in addressing food security challenges, particularly in regions vulnerable to climate change. Powered by AI, precision agriculture enables farmers to maximize crop yields while minimizing resource usage. Machine learning models analyze soil health, weather data, and crop conditions to provide tailored recommendations, enhancing agricultural productivity. Furthermore, AI-driven supply chain optimization reduces food waste by improving the efficiency of storage, transportation, and distribution systems. These contributions are vital for realizing SDG 2's vision of ending hunger and promoting sustainable agriculture (Leal Filho et al., 2022).

2.2.5. SDG 14 and 15: Life Below Water and Life on Land

Preserving biodiversity and ecosystems is central to SDG 14 (life below water) and SDG 15 (life on land). AI tools are increasingly used for environmental conservation efforts. For instance, computer vision systems monitor wildlife populations and detect illegal poaching activities, while machine learning models predict the impact of human activities on ecosystems. In marine conservation, AI aids in tracking the movement of fish populations, mapping coral reefs, and identifying sources of pollution. These technologies enable targeted and effective interventions to protect natural habitats (Isabelle & Westerlund, 2022).

3. Strategic Framework for AI-Driven Project Optimization

3.1. A Theoretical Framework for AI Integration

A strategic framework for AI-driven project optimization begins with integrating AI technologies across all phases of project management: design, monitoring, and implementation. This framework combines data-driven decision-making, real-time analytics, and resource optimization, enabling projects to achieve greater efficiency, scalability, and sustainability.

In the design phase, AI enables predictive modeling and scenario analysis, allowing project managers to anticipate challenges and allocate resources effectively. AI-powered tools continuously assess progress against predefined goals, identify bottlenecks, and suggest course corrections during monitoring. In the implementation phase, AI systems automate routine tasks, enhance coordination among stakeholders, and ensure the optimal deployment of resources. Together, these elements create a holistic approach that aligns project outcomes with organizational objectives and sustainable development goals (SDGs).

The framework also emphasizes adaptability and responsiveness, enabling organizations to navigate dynamic environments. By leveraging AI's ability to process vast amounts of real-time data, project teams can pivot strategies to address emerging challenges or seize opportunities. This flexibility is vital for projects addressing complex, multi-dimensional issues like climate change, urban development, or global health.

3.2. Key Components of the Framework

3.2.1. Data-Driven Decision-Making

Data-driven decision-making is the foundation of any AI-driven project optimization framework. By collecting, analyzing, and interpreting data from various sources, AI systems provide actionable insights that enhance strategic planning. For example, machine learning algorithms can identify trends and predict outcomes, enabling managers to make informed decisions about resource allocation and risk mitigation.

This approach minimizes reliance on intuition or outdated information, ensuring that decisions are based on empirical evidence. In sustainable development projects, data-driven strategies can optimize water distribution in arid regions, improve supply chain efficiency for humanitarian aid, or prioritize renewable energy investments based on regional demand patterns.

3.2.2. Real-Time Analytics

Real-time analytics, another key component, empowers organizations to monitor project performance dynamically. AI systems continuously process live data streams from sensors, IoT devices, and digital platforms, providing instant feedback on key performance indicators (KPIs). For instance, in urban transportation projects, real-time analytics can assess traffic patterns and optimize routes to reduce congestion and emissions. Similarly, in disaster response, AI-powered analytics can track the movement of relief supplies, ensuring timely delivery to affected areas. The ability to respond to issues as they arise enhances efficiency, reduces delays, and improves overall project outcomes.

3.2.3. Resource Optimization

Resource optimization is critical for maximizing the impact of limited resources, particularly in sustainability-focused projects. AI technologies such as optimization algorithms and predictive models ensure that financial, human, and natural resources are allocated where they are most needed. For example, AI can optimize energy consumption in smart buildings by adjusting heating, cooling, and lighting systems based on occupancy and weather conditions. In agriculture, AI-powered tools recommend precise amounts of water, fertilizers, and pesticides, reducing waste and enhancing productivity. By minimizing resource inefficiencies, AI contributes to cost savings and environmental sustainability.

3.3. Addressing Challenges

3.3.1. Ethical Considerations

The use of AI in project optimization raises several ethical concerns, including bias in algorithms, transparency, and accountability. AI systems can perpetuate inequalities and produce unfair outcomes if trained on biased data. For instance, in social programs, biased algorithms might inadvertently exclude marginalized groups from receiving benefits.

Organizations must adopt ethical AI practices to address these challenges, such as auditing algorithms for bias, ensuring transparency in decision-making processes, and involving diverse stakeholders in AI development. Ethical frameworks must also prioritize the human-centered design of AI systems, emphasizing inclusivity and fairness.

3.3.2. Data Security

AI systems rely heavily on data, making data security a critical concern. Unauthorized access to sensitive information can compromise projects, harm stakeholders, and erode public trust. For example, a data breach in a healthcare project could expose patient records, violating privacy rights and undermining the project's credibility.

Organizations must implement robust cybersecurity measures, such as encryption, access controls, and regular audits, to protect data integrity. Additionally, adhering to international data protection standards, such as the General Data Protection Regulation (GDPR), ensures compliance with legal and ethical obligations.

3.3.3. The Digital Divide

The digital divide poses a significant barrier to adopting AI-driven frameworks, particularly in low-income and rural areas. Limited access to digital infrastructure, high costs of AI technologies, and inadequate digital literacy prevent many communities from benefiting from AI advancements.

Bridging this divide requires digital infrastructure investments, affordable technology access, and capacity-building initiatives. Governments, non-governmental organizations, and private sector stakeholders must collaborate to ensure that AI technologies are accessible and inclusive, particularly for underrepresented populations.

4. Impact Assessment and Policy Implications

4.1. Accelerating SDG Outcomes Through AI-Driven Project Optimization

The adoption of AI-driven project optimization has the potential to significantly accelerate the achievement of Sustainable Development Goals (SDGs). By leveraging advanced analytics, machine learning, and automation, AI can enhance the efficiency and effectiveness of projects across various sectors, ensuring resources are utilized optimally and challenges are addressed proactively. For instance, in SDG 7 (Affordable and Clean Energy), AI-powered systems can optimize energy grids, balance supply and demand, and predict maintenance needs for renewable energy infrastructure. This minimizes downtime and reduces energy wastage, fostering the transition to sustainable energy sources. Similarly, AI-driven precision agriculture directly supports SDG 2 (Zero Hunger) by improving crop yields, minimizing resource inputs, and reducing food waste across supply chains (C. Li, 2023).

AI also enhances the scalability of projects aimed at SDG 3 (Good Health and Well-being). Predictive analytics in healthcare can forecast disease outbreaks, optimize resource allocation during emergencies, and personalize treatment plans, thus improving health outcomes on a global scale. In SDG 13 (Climate Action), AI-powered climate models provide actionable insights for mitigating environmental risks and devising effective climate adaptation strategies (Asi & Williams, 2018). Moreover, AI enables stakeholders to measure progress toward SDG outcomes with unprecedented accuracy. Real-time monitoring tools provide data on key performance indicators (KPIs), helping stakeholders evaluate the impact of their initiatives. These capabilities ensure that interventions are timely, targeted, and aligned with the overarching goals of sustainability (Walshe, Casey, Kernan, & Fitzpatrick, 2020).

4.2. The Role of Policymakers in Fostering AI Adoption

Policymakers are pivotal in creating an enabling environment for adopting and integrating AI technologies. By establishing supportive legal frameworks, ethical guidelines, and funding mechanisms, policymakers can ensure that AI is deployed responsibly and inclusively. Developing clear and adaptive regulatory frameworks is essential for fostering innovation while mitigating potential risks associated with AI adoption. Policies must address data privacy, algorithmic bias, and accountability issues to ensure public trust in AI systems. For example, regulations like the European Union's General Data Protection Regulation (GDPR) provide a model for safeguarding data while promoting technological innovation.

To ensure equitable AI deployment, policymakers must establish ethical guidelines prioritizing transparency, fairness, and inclusivity. These standards should mandate rigorous testing of AI algorithms to eliminate biases and ensure that marginalized communities are not excluded from the benefits of AI-driven projects. Ethical standards should also emphasize the importance of human oversight in AI decision-making processes to prevent unintended consequences. Policymakers must prioritize investments in digital infrastructure, particularly in low-income and rural areas. This includes expanding internet connectivity, improving access to affordable hardware, and supporting digital literacy programs. By bridging the digital divide, policymakers can ensure that AI technologies are accessible to all, fostering inclusive and equitable development.

Governments can accelerate AI adoption by offering financial incentives for innovation, such as grants, tax breaks, and public-private partnerships. Funding research and development initiatives, particularly those focused on sustainability, can spur technological advancements directly supporting SDG outcomes.

4.3. Cross-Sector Collaboration Opportunities

Achieving the full potential of AI-driven project optimization requires collaboration across sectors, including governments, non-governmental organizations (NGOs), and private entities. Each sector brings unique strengths and resources that, when combined, can amplify the impact of AI technologies on sustainable development. Governments and NGOs share a mission of addressing societal challenges, making them natural partners for sustainability initiatives. NGOs often have deep local knowledge and access to vulnerable populations, while governments can provide resources, regulatory support, and policy alignment. For example, in disaster response scenarios, governments can leverage NGO networks to deploy AI tools to map affected areas, optimize resource distribution, and ensure timely relief efforts (Lambin & Thorlakson, 2018).

The private sector is crucial in driving innovation and scaling AI solutions. Technology companies, in particular, have the expertise and resources to develop cutting-edge AI tools tailored to sustainability challenges. Collaborating with governments and NGOs, private entities can co-create solutions that address pressing issues such as climate change, food security, and public health. For instance, partnerships between tech firms and agricultural organizations have led to the development of AI-powered tools for precision farming, benefiting smallholder farmers and promoting food security. International collaboration is essential for addressing transboundary challenges such as climate change, biodiversity loss, and pandemics. Regional alliances, such as the African Union's Agenda 2063, can incorporate AI-driven strategies to address shared challenges while fostering economic growth and sustainable development. Global platforms like the United Nations can also facilitate knowledge exchange, standard-setting, and resource mobilization to support large-scale AI adoption (Wamba-Taguimdje, Wamba, Kamdjoug, & Wanko, 2020).

Effective AI deployment requires the involvement of diverse stakeholders, including academia, civil society, and local communities. Academic institutions can contribute by researching AI's applications and implications, while civil society organizations can advocate for ethical and inclusive AI practices. Local communities, as beneficiaries and participants, provide critical insights into the real-world challenges that AI technologies must address (Mikhaylov, Esteve, & Campion, 2018).

5. Conclusion

Artificial intelligence has proven to be a transformative tool in addressing the challenges and seizing the opportunities inherent in sustainable development. Its ability to process vast amounts of data, make precise predictions, and automate complex processes has positioned it as a critical driver of efficiency across energy, healthcare, agriculture, and urban planning sectors. By aligning its capabilities with the Sustainable Development Goals, AI has become a pivotal instrument in enhancing efficiency, reducing waste, and enabling data-driven decision-making. This alignment particularly impacts goals like clean energy, sustainable cities, and climate action, ensuring projects are impactful and adaptable in addressing evolving global challenges.

To unlock the full potential of AI in sustainable development, stakeholders across public and private sectors must adopt a coordinated and inclusive approach. Robust policy frameworks are essential to foster innovation while addressing critical issues such as data privacy, algorithmic bias, and public accountability. Investments in digital infrastructure, particularly in under-resourced areas, are necessary to bridge the digital divide and ensure that AI-driven solutions are accessible to all. Cross-sector collaborations, particularly through public-private partnerships, can pool resources, share expertise, and address shared goals, fostering transparency and mutual accountability. Additionally, capacity-building initiatives, such as training programs and digital literacy campaigns, will enhance technical expertise while promoting a culture of innovation and responsible AI use.

Finally, ethical considerations and grassroots participation are paramount for ensuring AI solutions are equitable, contextually relevant, and widely accepted. Stakeholders must prioritize transparency, mitigate biases, and establish accountability mechanisms while addressing cybersecurity challenges to protect sensitive data. Scaling proven AI solutions and tailoring them to local needs can maximize their impact, particularly in agriculture and healthcare. By involving communities at every stage of AI-driven project implementation, stakeholders can foster ownership and inclusivity, ensuring sustainable development outcomes that are impactful, equitable, and globally resonant.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed

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