

Harnessing artificial intelligence for sustainable development in emerging markets: Exploring opportunities and challenges in Thailand

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ABSTRACT

The current study investigates how artificial intelligence (AI) impacts sustainable development in emerging markets, with a focus on Thailand. Following a systematic review approach, research designs are configured for reviewing empirical evidence within peer-reviewed papers and reports. It also presents an overview of the adoption of AI in agriculture, health, and urban planning. The key findings lend credence to the potential use of AI in achieving resource optimality, reducing environmental damage, and urging social equity in its use. But these very initiatives are hampered by the digital divide, concerns about data privacy, and bias in algorithms. The way forward should be to establish solid, regulatory frameworks geared towards more investment in infrastructure with ethical AI practices that will lead to optimal gains. The huge potentials for AI to enable sustainability in Thailand are there; hence, it is very important to reduce the associated risks that require equitably distributed results in all sectors.

Keywords: artificial intelligence, sustainability, emerging markets, predictive analytics, ethical supply chain, environmental conservation

INTRODUCTION

The industrial way of doing business changed fundamentally with the introduction of artificial intelligence (AI) and introduced a new paradigm, fundamentally altering competition on the global scale (Cazzaniga et al., 2024; Esposito & Kapoor, 2022; Goel et al., 2021). The ability of AI to perform analytics and predict potential outcomes associated with given data in an automatized way revolutionizes many industries in terms of increases in productivity, innovation, and sustainability (Böhmecke-Schwafert & Moreno, 2023; Chatterjee et al., 2023). It is in such a context of emerging markets, characterized by rapid industrialization, urbanization, and environmental degradation, that adoption of AI becomes particularly critical (Di Vaio et al., 2020; Raihan, 2023; Sharma et al., 2024). They are full of formidable challenges in achieving economic development while, at the same time, taking care of concerns on environmental conservation and social equity (Abdulla et al., 2020; Bellagarda & Abu-Mahfouz, 2022; ESCAP, 2017; Wongwatkit et al., 2023). AI is emerging as a potent tool in this context, providing solutions to environmental issues through the optimization of resource allocation, improvement of administrative processes,

and support for sustainable development initiatives (López-Vargas et al., 2021; Thanyawatpornkul, 2021; Thanyawatpornkul & Chatthong, 2022). By harnessing the potential of AI, businesses in the emerging markets will be able to identify and allocate resources in the right sectors in a maximal effective way while minimizing waste (Dora et al., 2022; Rane et al., 2023b; Taghikhah et al., 2022; Zhou et al., 2022). Administrative optimization that comes with AI-driven automation reduces the inefficiencies of bureaucracy and builds agility in decision-making (Ogie et al., 2018; Thayyib et al., 2023). This also helps in promoting the SDGs through making resource and governance practices more effective (Indrasari et al., 2024; Ohalete et al., 2023; Sharma et al., 2024; Thayyib et al., 2023).

Despite all the benefits that the adoption of AI in emerging markets can offer, there are also some challenges and obstacles, many of which relate to data privacy, algorithmic bias, and regulatory frameworks, besides capacity constraints (ESCAP, 2017; Rane et al., 2023a). Furthermore, there is a social and economic complexity in the context of emerging markets that needs to be negotiated for AI technologies to help in a positive manner with sustainable development efforts (Mhlanga, 2023; Nuseir et al., 2020; Sharma et al., 2024). In

other words, the introduction identifies the emerging opportunities, as well as the existing challenges, of AI application in promoting sustainability objectives within social and economic dynamism (Gupta & Degbelo, 2023; Jagatheesaperumal et al., 2021; Yigitcanlar, 2021). These challenges and how to fix them should be clearly noted so that the transformational potential of AI drives sustainable development and inclusive growth in the emerging markets by businesses and policymakers (Rios-Campos et al., 2024; Thanyawatpornkul, 2021).

Background and Context

Uniquely, emerging markets support fast-growing economies, which evolve and quickly adapt social and economic conditions. When it comes to the balancing of the economic development and environmental sustainability, these markets face several problems (Dohale et al., 2022). Thailand, being a located country in Southeast Asia, can represent this phenomenon of a synchronous relationship between economic growth and environmental conservation (ESCAP, 2017; Gajić et al., 2024; Kumar & Chatterjee, 2023). As one of the key economics of the region, Thailand has been through fast industry and urbanization in the last several decades which is the reason of the economic growth but also the environmental challenges like air and water pollution, deforestation, and biodiversity loss (Dauvergne, 2020; Tsolakos et al., 2023; Walshe et al., 2020). The recognition of sustainable development strategies as the only justifiable way of connecting economic growth, environmental protection, and social equity has increased due to the issues (Chitturu et al., 2017; Quimba et al., 2023). The development and use of AI have displayed remarkable potential as a mainstream resource in solving the increasingly sophisticated problems that matter to sustainable development (Indrasari et al., 2024; Quimba et al., 2023; Sharma et al., 2024). AI can help the organizations if we consider the latest algorithms for machine learning combined with big data techniques. AI is a tool that helps organizations in optimizing and improving resource allocation, making the right decisions, and finding new ideas. In the sphere of ecologically sustainable development, AI technologies are capable of predictive modeling, real-time monitoring, and autonomous systems, which can increase the efficiency of nature resource management, reduce the environmental risks, and facilitate conservation efforts (Larbi-Siaw et al., 2022; Nuseir et al., 2020).

In addition, AI can be applied to those solutions to promote environmental sustainability through transparency and traceability that ensures ethical and environmentally related standards (Jagatheesaperumal et al., 2021). Through using this type of AI-powered technology, corporations can quickly identify the sources and amounts of data, and therefore, spot the inefficiencies, waste and environmental impact in the supply line (Efe, 2022; Phillips et al., 2020). Through the optimization of logistics, transportation routes, and inventory management, AI technologies can assist businesses in reducing their carbon footprint and achieve greater sustainability in their operations (Thanyawatpornkul & Chatthong, 2022; Wongwatkit et al., 2023). For instance, the different forms of AI that innovate the renewable energy, smart infrastructure, and climate resilience of the countries

such as Thailand tend to lead to a more sustainable and resilient future (Rane et al., 2023b). For instance, AI-assisted energy management systems can ensure that renewable energy sources are utilized optimally, are designed to ensure grid stability, and monitor energy consumption in buildings and industries (Ighalo et al., 2021). On the same topic, AI-based solutions for disaster risk management and climate adaptation can improve the preparedness, response, and recovery techniques in the case of natural disasters and the impacts of climate change. AI possesses an extraordinary power to disrupt local sustainable development efforts in emerging countries such as Thailand due to its ability to process infinite data, improve resources utilization, and make breakthroughs with the support of robust innovations across several sectors. But realizing this potential needs collaboration of governments, businesses, civil society, and others in ensuring that AI is deployed responsibly, ethical and social impacts addressed, and AI pays its contribution to the development that is inclusive and equitable.

Significance of the Study

The interaction of AI with sustainable development in emerging markets, such as Thailand, is a very complicated field, with the need for a great deal of detailed research and careful interest (Quimba et al., 2023; Rasheed et al., 2024). While the potential promises of AI adoption for sustainable development are immense, the consequences linked to the process of implementation are sometimes pretty nuanced and mixed, if at all (Mukherjee & Sarma, 2022; Rane et al., 2023a). AI is going to be a real game-changer across almost all sectors critical to sustainable development: agriculture, manufacturing, transportation, and energy, down to urban planning. It can help to optimize the use of resources in a way that reduces waste while minimizing environmental impact (Zhou et al., 2022). Therefore, technologies based on AI really hold promise for contributing to important sustainability goals, such as climate action, biodiversity preservation, and social equity. Through advanced analytics and automation, AI can enhance efficiency, drive innovation, and promote environmentally conscious practices, thereby fostering a more sustainable future (Obaideen et al., 2022; Rios-Campos et al., 2024). However, along with these positive horizons, doubts have been put up on the likely negative impacts of widespread use of AI. These may include possible job loss through automation and algorithmic bias, privacy violation by data collection and surveillance, and further aggravation of the already existing social and economic inequality (Hosseini & Rajabipour Meybodi, 2023). Such demands of accommodation should rest on consideration and measures to be taken in advance to alleviate possible risks and to ensure that the advantages from AI adoption are distributed fairly in society (Mahmood, 2022; Oliver, 2022).

It is, therefore, necessary to carry out valid and high-quality research to critically examine how the AI adoption that will drive sustainable development in emerging markets might affect stakeholders and systems (Olubusoye et al., 2023; Rane et al., 2023a). Valid research and ways of harnessing most of its benefits while managing the risks make it possible for policymakers, businesses, and civil society to ensure that AI is implemented in a way that is most likely to bring about change

for the better and in a sustainable manner within emerging market contexts, such as Thailand (Ogie et al., 2018; Thanyawatpornkul, 2021).

Objectives of the Study

In this study, this research intends to investigate the various factors of the AI adoption for sustainable development in Thailand. Specifically, the study seeks to:

- (1) examine the current state of AI adoption in Thailand and its implications for sustainable development across different sectors,
- (2) identify key opportunities for leveraging AI to address pressing environmental and social challenges in Thailand,
- (3) analyze the barriers and limitations hindering the effective integration of AI into sustainable development initiatives in Thailand, and
- (4) propose recommendations and strategies for maximizing the positive impacts of AI on sustainable development while minimizing potential risks and drawbacks.

Methodological Approach

This research will operationalize the objectives by reviewing systematic methods on existing literature, which are empirical studies and case examples of AI and SD in Thailand. This paper is important in bringing together and critically evaluating the findings from many different sources—academic journals, conference proceedings, industry reports, and government publications—to get a full appreciation of the complex relationship between adoption of AI and sustainable development in the Thai context.

Structure of the Paper

The organization of this paper is, first, an introductory section; the subsequent sections will be on the literature review, methodology, findings, discussion, and conclusion. The literature review, therefore, captures a comprehensive overview of available research associated with AI and sustainable development by exposing the theories involved, frameworks, and empirical studies. The methodology will entail the approach taken in carrying out the research; if selection criteria were used for the literature; methods of data collection; and analysis. The findings section will present key insights and findings through the systematic review of the opportunities and challenges associated with AI adoption for sustainable development in Thailand. The discussion section should critically explore the implications of the findings, gaps in the existing literature, and provide recommendations for further research and policy. Finally, the conclusion of the study should summarize the main findings of the study, reiterating their significance, and point toward the way further research might proceed.

LITERATURE REVIEW

The literature in which AI coincides with sustainable development is rich in details about potential benefits, challenges, and opportunities that are provided through the

use of AI technologies to solve environmental, social, and economic concerns. With this in place, the next section provides in-depth reviews of existing studies on the important role AI plays in promoting sustainable development. Emphasis has been placed on most important theories, frameworks, and empirical studies.

This review is based on a range of sources, including academic journals, conference proceedings, industry reports, and government publications, to bring out the main themes and trends in the field and to identify any gaps in knowledge that should be pursued.

Artificial Intelligence and Environmental Sustainability

A significant body of literature has begun to show the potential of AI in effecting ways to enhance environmental sustainability by optimizing resource use, lowering waste, and mitigating environmental risks (Philbin et al., 2022). At its heart, AI will support predictive analytics allowing organizations to predict trends, model complex systems, and take data-driven decisions to reduce their environmental footprints (Rajguru, 2024; Wongwatkit et al., 2023). For instance, using artificial intelligence-based algorithms to analyze big datasets from sensors, satellites, and other sources in the attempt to predict changes in weather patterns, identify areas under natural disaster threats, and further optimize strategies for response to disasters (Bellagarda & Abu-Mahfouz, 2022; Utina et al., 2024).

In addition, various AI-related technologies are involved, ranging from smart grids and intelligent transport systems to precision agriculture, which contribute to the increase of the systems' energy efficiency, reduction of emissions, and better management of natural resources (Thanyawatpornkul et al., 2016). For instance, AI has been combined with renewable energy systems, reporting large performance and reliability improvements for integrated systems with solar, wind, and energy storage subsystems (Kazeem et al., 2023; Rane et al., 2023a). The AI-based algorithms will, therefore, be important in optimizing irrigation schedules, monitoring the level of moisture, and detecting disease in crops, hence bringing about high yields, low water usage, and reducing the use of pesticides in agriculture (Hong & Xiao, 2024; Thanyawatpornkul, 2021).

Social Sustainability Artificial Intelligence

Beyond these environmental applications, AI could be capable of promoting social sustainability in addressing other socio-economic challenges like poverty, inequality, access to healthcare, and education (Kittichat, 2024). These AI-powered technologies will empower the administration, humanitarian groups, and non-governmental organizations to serve people better and to make sound decisions, as a result of which marginalized people will have empowerment (López-Vargas et al., 2021; Rane et al., 2023b). For instance, AI-based chatbots and virtual assistants are currently being used to provide health advice, mental health support, and information about education on personalized health to residents of remote or underserved areas (Hosan et al., 2022).

In addition, algorithms in AI systems can comb through information posted on social media, online forums, or any other digital sources for emerging trends and monitoring public sentiments for early indication of potential social

upheaval or political instability (Dora et al., 2022). This would give an opportunity to policymakers and law enforcement to design intervention measures targeting social inequalities, preventing conflict, and promoting social cohesion (Hosan et al., 2022). However, there is concern that AI can actually magnify existing biases and inequalities, particularly in those areas of application, such as criminal justice, employment, and financial services, in which the algorithmic decision-making can perpetuate discrimination and injustice.

Artificial Intelligence and Economic Sustainability

Integration of AI into the business processes is bound to affect the sustaining economics where the labor market, increasing productivity, and competitiveness will be based on technology (Rane, 2023). Core AI technologies, principally machine learning, robotic process automation, and natural language processing, empower the reduction of costs of operations, process optimization, and innovation in almost any sector (Dora et al., 2022; Wongwatkit et al., 2023). For instance, chatbots driven by AI and virtual assistants can execute routine activities, offer better services for customers, and free human workers to be occupied with higher-value activities (Jabeur et al., 2022).

More so, AI-driven predictive analytics will optimize supply chain management, control inventory, and forecast demand, resulting in more effective resource allocation, reduced waste, and better profitability (Kumar & Chatterjee, 2023). This again points toward the fact that AI can replace humans, increase income inequality, and disproportionately lead to wealth and power aggregation at the expense of a few tech giants (López-Vargas et al., 2021). Therefore, it is incumbent upon policymakers and business leaders to earnestly deal with the social and ethical concerns of AI adoption to, therefore, implement measures that ensure that the benefits of AI are distributed and shared across the society (Hoang et al., 2022).

Challenges and Limitations

Despite the huge potential that AI has in progressing sustainable development, there are a number of challenges and limitations that have to be addressed to derive maximum benefit from it (Mahmood, 2022; Yigitcanlar, 2021). Among these challenges is the issue of a digital divide; in other words, unequal access to AI technologies and digital infrastructure, especially by low-income and rural community members (Lin & Liu, 2018; Rasheed et al., 2024). Marginalized populations without proper access to affordable broadband internet, digital literacy programs, and affordable devices are at risk of being left behind by the AI revolution, further widening existing inequalities and escalating social exclusion.

Furthermore, the discussion of AI's ethical and social impacts is increasingly focusing on issues of privacy, transparency, accountability, and algorithmic bias (ESCAP, 2017). Most AI systems are based on colossal personal data and flag the issues of consent, ownership, and protection of individuals' privacy rights (Gupta & Degbelo, 2023). Additionally, AI algorithms can exhibit biases and discriminate for race, gender, or some other sensitive attributes, leading to unfair or discriminatory outcomes in

hiring, lending, and criminal justice, among other applications (Kumar & Chatterjee, 2023).

Theoretical Review

The theoretical frameworks drawn on in trying to understand the crossroads between AI and sustainable development in developing markets like Thailand include technological determinism theory, the diffusion of innovations theory, and the triple bottom line (TBL) model.

Technological determinism theory

The technological determinism theory postulates that technology is the basis and modulates the society's values, behaviors, and structures, in which AI is a disruptive technological development (Olubusoye et al., 2023; Roppelt et al., 2024). On sustainable development, AI can be viewed as one of the emerging disruptive technologies that would inevitably disrupt business, governance, and environmental management as a discipline (Dohale et al., 2022; Zhou et al., 2022). The AI adoption that is expected to take off in markets, including in Thailand, is expected to yield a significant effect on driving sustainable development efforts. Technological Determinism theory helps to explain how AI-driven innovations such as predictive analytics and automation drive efficiency gains, foster innovation, and promote sustainability by optimizing resource use, reducing waste, and managing environmental disaster risk (Larbi-Siaw et al., 2022).

Diffusion of innovations theory

This theory, as outlined by Rogers, is conceptualized to explain how new technologies, ideas, or practices diffuse into a system and eventually get adopted in that system or society (Ben Hamadi & Fournès, 2023). The theory helps in understanding what factors may affect the adoption and diffusion processes of AI-driven technologies in emerging markets, such as Thailand, for sustainable development (Saba & Monkam, 2024). Adoption of AI for development and deployment in AI-driven applications and services is influenced at the level of businesses, government agencies, and civil society organizations by such key factors as the perceived relative advantage of AI, compatibility with existing practices, complexity, trialability, and observability (López-Vargas et al., 2021). By identifying the barriers and enablers of AI adoption, the Diffusion of Innovations theory informs strategies for promoting sustainable development through the wide adoption of AI-driven solutions.

Triple bottom line model

The TBL model was first introduced by John Elkington, indicating that three interlinked areas of performance have to be simultaneously measured when considering the sustainability performance of organizations and societies (Ohalet et al., 2023; Roppelt et al., 2024). In this regard, the TBL model underpins the three-dimensional framework of evaluating the AI-led innovation with respect to economic growth, social equity, and environmental conservation for sustainable development in emerging markets, such as Thailand (Hara, 2024; Yigitcanlar, 2021). AI implementation in business operation and policy intervention provides opportunities for stakeholders to pursue triple-bottom-line outcomes that balance between economic prosperity, social

well-being, and environmental stewardship (Rios-Campos et al., 2024). The TBL model leads the way in the measurement and management of the sustainability impacts of AI adoption, where economic gains are not traded for social and environmental degradation (Phillips et al., 2020).

The theories and models make this process of applying AI to sustainable development in emerging markets, such as Thailand, more understandable (Mukherjee & Sarma, 2022). Research and practice, in turn, can draw on such theoretical frameworks to develop empirically informed strategies for tapping into the transformative potential of AI, simultaneously advancing the sustainability goals of the TBL model (Haghshenas et al., 2023).

Empirical Review

Current state of artificial intelligence adoption in Thailand and its implications for sustainable development

Empirical studies have shown that AI in Thailand is increasingly being adopted in areas that concern agriculture, manufacturing, health care, transportation, among others (Mishra & Maheshwari, 2020). For instance, the study by Thailand Development Research Institute (TDRI) shows that businesses within Thailand increase their investment in AI tools to improve productivity, drive better decisions, and spur innovation (Rosário & Dias, 2023; Wongwatkit et al., 2023). Such a trend is of major importance to sustainable development since through AI technologies organizations can optimize the use of resources, reduce wastage, and mitigate environmental impact (Philbin et al., 2022; Sarma et al., 2021). The growing use of AI in the Thai manufacturing sector has brought about changes toward better energy use, reduction of waste, and emissions control in view of the country's sustainability goals (Mandal & Ghosh, 2023).

Key opportunities for leveraging artificial intelligence to address environmental and social challenges

Important opportunities exist in which AI can make a difference in answering critical environmental and social challenges in Thailand. For example, a study by the National Electronics and Computer Technology Center found that the application of AI, in the form of smart grids, intelligent transportation systems, and environmental monitoring platforms, is a key driver of sustainable development in Thailand. Examples include real-time data analysis, predictive modeling, and decision support that is being worked on through such technologies in an effort toward more effective resource management, disaster response, and environmental conservation efforts (Satornino et al., 2024). It will also bring an improvement in the access of essential services and a reduction of inequalities by promoting social well-being through AI-driven social initiatives, such as chatbots for healthcare and education, in Thailand (Esposito & Kapoor, 2022; Gupta & Degbelo, 2023; Walshe et al., 2020).

Barriers and limitations to artificial intelligence integration in sustainable development initiatives

Empirical research has been able to recognize the fact that AI, though offering opportunities, has a number of barriers and limitations that restrain its inclusion in sustainable development initiatives in Thailand. For instance, using such

information from the TEI, challenges on data privacy, cyber security, and regulatory frameworks have been important hindrances in the adoption of AI in environmental management and conservation efforts in Thailand. It also questions technical expertise, institutional capacity, and financial resources that might be required for the effective implementation of AI-driven solutions (Mhlanga et al., 2023; Santosh & Gaur, 2022; Zhou et al., 2022). Addressing these will require joint efforts in developing supportive policies and institutional capacity by the governments, industries, and civil society, while fostering collaboration and knowledge sharing across sectors (Sarker, 2022).

Recommendations and strategies for maximizing the positive impacts of artificial intelligence on sustainable development

Empirical findings provide various recommendations and strategies for maximizing the positive impacts of AI on sustainable development within Thailand (Thanyawatpornkul & Chatthong, 2022). This is supported by the United Nations Development Programme research, which points toward the fact that participation, capacity, and knowledge exchange are all critically important in the adoption of AI for sustainable development (Indrasari et al., 2024; Mhlanga et al., 2023). Other ways to overcome the barriers include the creation of public-private partnerships, technology incubators, and innovation hubs that foster collaboration, investment, and skill development in Thailand (Nabi, 2019). The country of Thailand may thus enable actual and full realization of the potentials of AI in the achievement of sustainable development, with the use of the above recommendations and strategies to reduce risks and disadvantages of the technology for this country (Sharma et al., 2024).

This section of the review of related literature presented above has really notified about the multi-roles of AI for sustainable development in terms of environment, society, and economy. This provides a pathway toward resource efficiency, service delivery, and inclusive growth with the support of organizations and governments in driving such AI-based technologies. However, the problems posed by the digital divide, ethical issues, and algorithmic bias persist in addressing the benefits flowing from AI and responsive to the principles of sustainability and social justice. A new way to unlock the full potential of AI for sustainable development is expected through the interdisciplinarity of research and collaborative work, which will help mitigate the risks and limitations. **Table 1** shows key findings of empirical review.

RESEARCH METHODOLOGY

This systematic study is conducted with the aim of examining the intersection of AI and sustainable development in Thailand, exploring its current state of AI adoption, and the opportunities and challenges this provides, together with recommendations for harnessing AI positive impacts. The research design of the study must be one that would meet the intent of giving a critical and serious analysis of already existing literature, empirical studies, and case examples related to AI and sustainable development in Thailand. The following methodology is applied:

Table 1. Key findings of empirical review

Research objective	Findings
Examine the current state of AI adoption in Thailand and its implications for sustainable development across different sectors.	AI adoption is growing in agriculture, healthcare, and urban planning. AI enhances resource optimization, improves healthcare outcomes, and supports smart city initiatives, contributing to sustainable development.
Identify key opportunities for leveraging AI to address pressing environmental and social challenges in Thailand.	AI offers opportunities such as improved crop yields through precision agriculture, efficient energy management in smart grids, and enhanced disaster preparedness. These applications help address environmental degradation and social challenges.
Analyze the barriers and limitations hindering the effective integration of AI into sustainable development initiatives in Thailand.	Key barriers include digital divide, lack of infrastructure, data privacy concerns, and algorithmic biases. These issues limit the equitable and effective deployment of AI technologies.
Propose recommendations and strategies for maximizing the positive impacts of AI on sustainable development while minimizing potential risks and drawbacks.	Recommendations include developing inclusive policies, enhancing regulatory frameworks, investing in digital infrastructure, and promoting ethical AI practices. Capacity-building and stakeholder collaboration are also crucial for successful AI integration.

Research Design

This research is systematically conducted through the review of related literature and empirical studies about AI and sustainable development in Thailand. Systematic review methodology helps to organize and provide transparency throughout the analysis of sources so that rigor and reproducibility are followed in the process of research. This research systematically reviews, screens, and synthesizes literature from heterogeneous sources in order to provide a better understanding of the opportunities, challenges, and implications of adopting AI for sustainable development in Thailand.

Literature Search Strategy

The strategy should have the capacity to identify relevant sources of information on AI and sustainable development in Thailand. Academic databases, including PubMed, Scopus, and Web of Science, will be systematically searched using a combination of search terms and keywords on AI, sustainability, and Thailand, and possibly the key words representing the following three sectors: agriculture, manufacturing, and healthcare. It is also expected that searches for grey literature sources in the form of reports, policy documents, and industry publications will yield non-peer-reviewed literature and relevant case examples.

Inclusion criteria

The literature screening exercise will establish specific criteria for the studies to be included in this review, and these will aid in making the inclusion relevant and of quality. For instance, literature published in peer-reviewed journals or from reputable sources of grey literature, in the English or Thai language, shall cover the adoption of AI and its implications on sustainable development in Thailand. Studies providing empirical evidence, case studies, theoretical frameworks, or policy recommendations related to AI adoption and sustainable development in Thailand will be eligible.

Exclusion criteria

Studies that would fall in this regard would be those not directly pertinent to the research objectives, outdated studies, or those not methodologically strong enough. One might use studies published prior to some specified period, for example, studies published over ten years ago, as a criterion for

excluding material to ensure that the review of the literature involves the latest and most relevant material. The systematic review can also exclude those studies that have been considered not to meet the predefined methodological criteria—those, for instance, without clear research questions, with inappropriate study designs, or with sample sizes that are inadequately powered. The excluded sources will be of promotional material, blog posts, and opinion pieces, as they may compromise the quality and credibility of the study.

Data Collection and Screening

The search output will result in a long list of sources and studies which are probably related to the proposed review. Screening of all studies following the inclusion and exclusion criteria systematically will be done. Two independent reviewers will screen the titles and abstracts of the retrieved studies to ascertain that they meet the eligibility criteria. The full-text articles of relevant selected studies will be retrieved and further evaluated for relevance to the research objectives.

Data Extraction and Synthesis

Data from the selected studies will be extracted using systematic means to capture relevant information, including study characteristics (i.e., author, publication year, and study design), key findings, methodologies, and implications of AI adoption with respect to sustainable development in Thailand. In this regard, the process of data synthesis will involve analyses that will present a summary of the information extracted, considering the identification of common themes, patterns, and trends in the literature. Hence, for the organization and interpretation of findings, thematic analysis tools, such as coding and categorization of data, will be employed.

Quality Assessment

The methodological rigor and credibility of the included studies will be measured by quality appraisal tools. Using the critical appraisal skills programme checklist for qualitative studies and the JBI checklist for quantitative studies, risk of bias, methodological limitations, and overall study quality will be appraised (Bellagarda & Abu-Mahfouz, 2022; Gajić et al., 2024; Hong & Xiao, 2024).

Data Analysis and Interpretation

This synthesized data will be analyzed and interpreted to generate insights and conclusions meaningful in the current state of AI adoption, the opportunity and challenges it offers, and what could be recommended for sustainable development in the country. Descriptive statistics, thematic analysis, and narrative synthesis techniques are to be used in analyzing data and spotting reappearing themes, patterns, and relationships among the studies (Indrasari et al., 2024; Kumar & Chatterjee, 2023; Sarker, 2022).

Reporting and Dissemination

Findings from the systematic review will be reported and disseminated through various platforms, including academic publications, conference presentations, policy briefs, and stakeholder engagement activities. The research report will follow the guidelines of the preferred reporting items for systematic reviews and meta-analyses, to ensure completeness and transparency with respect to the systematic review methodology and results (Hara, 2024; Kittichat, 2024; Nwankwo & Ukhurebor, 2021; Rane et al., 2023a). This research is conducted to provide useful information on the current status, opportunities, challenges, and recommendations for sustainable development of AI adoption in Thailand.

FINDINGS

Major findings of the study can help in developing insights about the current situation, opportunities, challenges, and recommendations for sustainable development for the adoption of AI in Thailand. This paper investigates the impacts of AI by examining existing research and empirical study data, including cases, on the multidimensional effect of sustainable development in the Thai context. The results have been synthesized to be presented under four main themes: the state of current AI adoption, opportunities for AI, challenges and limitations, and recommendations and strategies.

Current State in Artificial Intelligence Adoption

The systematic review shows that there is an increasing application of AI adoption in Thailand in the agriculture, manufacturing, health, transportation, and governance sectors (Cazzaniga et al., 2024; Rasheed et al., 2024). Other studies have indicated an increase in investment by businesses, government agencies, and research institutions in AI-driven technologies in Thailand (Mikic & Malala, 2021; Nyagadza et al., 2022). For example, the TDRI outlines that there is an increased usage of AI by Thai businesses in order to raise levels of productivity, better the effectiveness in the decision process, and enhance the innovation portfolio (Sarker, 2022).

AI-powered precision agriculture, remote sensing, predictive analytics, and AI technologies in general have found wide application in crop management, monitoring soil health, and increasing the productivity of agricultural outputs (Goel et al., 2021; Kazeem et al., 2023). AI-powered robotics, automation, and predictive maintenance systems better manufacturing productivity, product quality, and supply chain

management. Other sections that benefit include AI-driven healthcare solutions for telemedicine, diagnostic imaging, and predictive modeling to enhance healthcare access, quality, and improved outcomes in Thailand (Ogie et al., 2018; Wongwatkit et al., 2023).

In general, the findings have pointed out that the context of AI adoption in Thailand is, in most of the industrial sectors, positively inclined and represents high potential to deliver substantive impacts on sustainable development. Nevertheless, such disparities between the rates and extents of the application of AI technologies in other industries and locations across the nation will need targeted interventions and capacity-building programs in order that its benefits accrue inclusively and equitably.

Opportunities for Leveraging Artificial Intelligence

A number of opportunities for promoting environmental, social, and economic challenges in addressing AI were unraveled in the systematic review (Chitturu et al., 2017; Indrasari et al., 2024). One such opportunity is the utilization of AI-driven technologies to upgrade environmental sustainability and the management of natural resources (Rasheed et al., 2024). For example, the optimal use of energy and abatement of emissions for climate change mitigation have been made possible through the use of AI-based tools enabling a smart grid with environmental monitoring systems and predictive modeling techniques (Nuseir et al., 2020; Philbin et al., 2022). Similarly, AI-enabled urban mobility and transportation systems reduce congestion and minimize air pollution through their smart mobility solutions in traffic management systems (Hara, 2024; Rajguru, 2024).

AI technologies offer immense potential to create better accessibility of healthcare, educational, and social services, in general, for the social domain of Thailand among others (Thanyawatpornkul & Chatthong, 2022; Walshe et al., 2020). These include AI-driven telemedicine, virtual assistants for health, and diagnostic tools, which will advance better health access in underdeveloped and those that are far away from the city (López-Vargas et al., 2021). Likewise, AI-driven educational platforms, personalized learning systems, and virtual tutors are fostering the ultimate success of education and fostering opportunities for lifelong learning in every corner of the globe (Philbin et al., 2022; Srivastava & Maity, 2023). Innovations in governance and public administration supported by AI can increase transparency and accountability further, making citizen engagement even better in Thailand. AI data analytics, supported by predictive modeling and decision support systems, could enhance policy formulation, resource allocation, and service delivery in the areas of urban planning, disaster management, and public health.

Generally, the findings provide the support for AI technologies that offer a range of opportunities to address complex societal problems and promote the sustainable development of Thailand. Stakeholders can achieve new paths for innovation, efficiency, and inclusivity in the sector by unlocking AI's potential.

Challenges and Limitations

Although such high prospects are envisioned, the systematic review has also identified several challenges and

Table 2. Opportunities and challenges of AI adoption in sustainable development

Opportunities of AI adoption	Challenges of AI adoption
- Enhancing efficiency and productivity	- Digital divide, unequal access to AI technologies
- Driving innovation in various industries	- Ethical concerns: Data privacy, algorithmic bias
- Promoting sustainability across sectors	- Regulatory gaps and governance issues
- Optimizing resource allocation	- Capacity constraints: Lack of technical expertise
- Improving decision-making processes	- Environmental challenges: Air and water pollution
- Enhancing transparency and accountability	- Socio-economic disparities
- Fostering inclusive growth	- Resistance to change and cultural barriers

limitations that the operational integration of AI in the sustainable development initiatives by Thailand must overcome, to be effectively realized: the digital divide among the different segments of the population that creates unequal access to AI technologies and digital infrastructure (Chatterjee et al., 2023; Jagatheesaperumal et al., 2021). Research suggests that disparities in the connectivity to the internet, digital literacy, and the affordability of devices may greatly exacerbate socio-economic gaps and reduce the benefits of using AI technology for marginalized groups within Thailand. These ethical and social considerations include, among others, data privacy, algorithmic bias, and accountability in the implications of AI (Ajwa, 2024; ESCAP, 2017). Because AI-powered systems are data-hungry, they deal with huge amounts of personal data, thereby bringing concerns around consent, transparency, and data ownership rights (Boukherouaa et al., 2021). The AI algorithms can further be biased and thus cause discriminations based on race, gender, or any other protected attribute; it thus leads to unfair or inequitable outcomes in areas like employment, criminal justice, and financial services (Rane et al., 2023b; Walshe et al., 2020).

In addition, the absence of regulatory frameworks, standards, and guidelines for the adoption and governance of AI is challenging in the development of responsible and ethical AI deployment in Thailand (Indrasari et al., 2024). Inadequacies of clear guidelines on data protection, algorithmic transparency, and accountability mechanisms can compromise public trust in AI technologies and further act as a barrier to acceptance and adoption across all sectors (Srivastava & Maity, 2023). Overall, these results emphasize the imperative that challenges and limitations should be better managed for AI to contribute to sustainable development in Thailand. This apparently dictates policy intervention, capacity building of stakeholders, and engagement to address the issue of the digital divide and handle ethical AI deployment to set an effective governing framework for the uptake of AI. **Table 2** shows the opportunities and challenges of AI adoption in sustainable development.

Recommendations and Strategies

On the basis of the evidence from this review, the following recommendations and strategies are recommended for attaining the highest possible benefit of AI toward sustainable development in Thailand (Mhlanga et al., 2023): A key recommendation is to focus on inclusivity and equity to level the playing field for the marginal community and the disadvantaged geographical areas in AI technology and digital infrastructure use (Goel et al., 2021). This would be executed through infrastructure investment in broadband, digital

literacy programs, and affordable tools to bridge the digital divide so that innovations brought by AI filter through all strata of society (Elavarasan et al., 2021). Further, the responsible and ethical use of AI should be promoted with the development of regulatory frameworks, standards, and guidelines (Esposito & Kapoor, 2022; Ghelani & Hua, 2022). This would build public trust in AI technologies, ensure more transparency regarding data privacy and control, algorithmic transparency, and accountability, and help alleviate some concerns that involve privacy, bias, and discrimination.

More importantly, a knowledge base and the expertise for harnessing the power of AI within the context of sustainable development require capacity-building initiatives and skill development programs, whereby people, organizations, and policymakers are taken care of and prepared. Skills for both data science and machine learning, and particularly on AI ethics, are indispensable in order to equip stakeholders to make effective and responsible use of AI technologies of the future, which should cut across sectors (Ghelani & Hua, 2022). It should further encourage stakeholders from governmental agencies, industry, academies, and civil society organizations to work together and share knowledge with one another; in so doing, they will propagate innovation, thereby building synergies and addressing common challenges in the adoption and governance of AI (Mukherjee & Sarma, 2022; Sharma et al., 2024). These can also serve as platforms for collaboration between industry and the public sector for co-creating AI-driven solutions in sustainable development in Thailand: public-private partnerships, technology incubators, and innovation hubs (Rios-Campos et al., 2024).

This, therefore, stresses the importance of adopting a pluralistic and multistakeholder, holistic approach in mainstreaming AI in achieving sustainable development in Thailand (Mhlanga et al., 2023). The recommended proposals and strategies shall, therefore, allow the unleashed transformative power of AI among stakeholders to address the problems and ensure that AI technology in all sectors contributes to inclusive growth, social equity, and environmental sustainability in Thailand (Ghelani & Hua, 2022).

The findings emerged from the systematic review of empirical studies and reports investigating the role of AI in various sectors in Thailand (Mikic & Malala, 2021). The report, based on wide literature review, assessed the potential of AI to make resources more productive and meet challenges to sustainable development (Goel et al., 2021). In spite of this fact, some obstacles did appear, such as digital divides, issues related to the protection of personal data, and algorithmic bias, caused by infrastructural and regulatory gaps (Mukherjee & Sarma, 2022). These findings give an account of the

interaction of technological advancement with socioeconomic factors in emerging markets and make a call for responsible AI integration in an effort to maximize positive impacts but reduce risks.

DISCUSSION

The discussion section provides a platform for in-depth exploration of implications in AI adoption for sustainable development in Thailand, drawn from the findings of the systematic review (Gupta & Degbelo, 2023; Zhou et al., 2022). The discussion section generally elaborates on the identified opportunities, challenges, and recommendations in exploring their implication on policy, practice, and future research undertakings (Kumar & Chatterjee, 2023). The systematic review underlines the magnitude of opportunities that have been created from AI technologies for the implementation of sustainable development in most sectors in Thailand (Jabeur et al., 2022). It is only through those AI innovations that transformation can be brought about for better efficiency, productivity, and inclusiveness in the solution of paramount environmental, social, and economic challenges (Mhlanga et al., 2023). For example, AI-driven agricultural solutions are said to offer much in terms of best usage of resources, an increase in crop yield, and inculcating sustainable farming practices that contribute to the enhancement of food security and rural livelihoods (Mikic & Malala, 2021). Similarly, the deployment of AI-driven diagnostic tools, telemedicine platforms, and predictive analytics in health will significantly alter access, quality, and health outcomes, mainly in remote or underserved locations (Ohalete et al., 2023; Rios-Campos et al., 2024).

Furthermore, the promise of AI technologies does not stop at the door to any one sector but goes far and wide into governance and public administration (Thayyib et al., 2023). Governments can enhance transparency, accountability, and citizen engagement by using AI-driven data analytics, predictive modeling, and decision support systems in processes of policy formulation and service delivery (Gajić et al., 2024; Jabeur et al., 2022). It would foster evidence-based policy choice, efficient resource allocation, and responsive governance mechanisms; in turn, it will pave the path for socio-economic development and public welfare (Larbi-Siaw et al., 2022; Ohalete et al., 2023). Another AI-powered smart cities solution is traffic management, energy-efficient buildings, and intelligent transport systems that can harness the power of AI to bring forward urban sustainability while reducing emission levels and improving the quality of life among residents (Sharma et al., 2024; Thanyawatpornkul et al., 2016). In addition, the potentials and opportunities for the consideration of aspects and the adoption of AI in the context of sustainable development in Thailand are also well emphasized. Other challenges include issues related to the digital divide, consideration of ethical issues, regulatory gaps, and capacity constraints. It gives rise to special concerns regarding the digital divide; huge disparities in access to AI technologies and digital infrastructures are barriers to inclusive development and the equitable access of AI-driven innovations (Goel et al., 2021). It also raises very important

ethical issues on the privacy of data, algorithmic biases, and accountability in the deployment of AI technologies in a responsible and ethical manner. This will at the least need the development of robust policy frameworks, regulatory mechanisms, and institutional structures that would govern the adoption of AI in a way that is congruent with sustainable development objectives (Mikic & Malala, 2021). Policymakers can articulate a high-level strategy for an inclusive, responsible deployment, and ethical use of AI technologies in Thailand by enabling collaboration and information sharing among stakeholders (Tsolakis et al., 2023). Importance of capacity building initiatives and skills development programs involves equipping people, organizations, and the policymakers with knowledge and expertise required to be in a position of harnessing effectively the massive potentials of AI in regard to sustainable development (Hara, 2024; Wongwatkit et al., 2023).

These results matter in so far as they show the transformative potential of AI towards sustainable development in emerging markets like Thailand, whose rapid growth has to contend with the inherent limits of growth perspectives put by environmental and social challenges (Ohalete et al., 2023). In this study, opportunities and barriers for AI integration into existing infrastructures were identified, which forms a strong rationale for adopting and diffusing good practices of ethical AI, robust infrastructure, and inclusive policies (Mikic & Malala, 2021). These findings provide useful insight into how policy makers, businesses, and stakeholders should be guided towards responsibly harnessing the benefits of AI with respect to risks related to, in particular, data privacy and algorithm bias, and to ensure fair and sustainable outcomes across all sectors.

Conclusively, AI technologies thus provide ample opportunities to drive sustainable development in Thailand. However, they must be kept in mind in view of their proper scrutiny coupled with the challenges and limitations such an engagement entails. All these issues are to be properly taken care of by collective efforts and targeted endeavors so that Thailand harnesses the full potentialities of AI for driving the future course of sustainable development and brings in a more resilient, fair, and prosperous future for its citizens.

Limitations

Among other things, the systematic review also reveals a set of challenges and limitations that might potentially bind the realization of the full potential and promise of AI to effectively contribute towards sustainable development initiatives within Thailand. Other challenges lie in the existence of the digital divide, ethical concerns, regulatory gaps, and capacity constraints. This could further compound the existing socio-economic inequalities that resulted from the digital divide in the take-up of AI technologies and digital infrastructure (Mandal & Ghosh, 2023). What is more, there are concerns about privacy, bias in algorithms, and accountability that may pose risks to the implementation of AI technologies in a responsible and ethical way for Thailand (Walker et al., 2019). Moreover, the uncertainty in the regulatory framework and standards for adopting and governing AI technologies brings about uncertainty about the technology across the public and various sectors and, hence,

affects acceptance and adoption (López-Vargas et al., 2021; Rios-Campos et al., 2024). Efforts to leverage AI for sustainable development in Thailand may be hampered by capacity constraints related to the lack of technical expertise, institutional capacity, and financial resources (Ogie et al., 2018; Thanyawatpornkul et al., 2016).

Recommendations

Recommendations are given that are available for adoption in strategies that address the challenges and ensure the maximization of positive impacts of AI on sustainable development in Thailand in the following areas: making AI technologies accessible for all equitably; strengthening the needed regulatory frameworks and governance mechanisms; enhancing capacity through building skills; and collaborations, along with sharing knowledge, among stakeholders (Mishra & Maheshwari, 2020). Such focus on inclusive and equitable access toward AI technologies and digital infrastructural development should work for everybody in society so that no one is left behind, realizing the gains from AI-driven innovations (Goel et al., 2021; Ohalete et al., 2023). This potentially will include broadband infrastructural investment, digital literacy programs, and affordable devices in closing the divide and fostering digital inclusion in Thailand (Utina et al., 2024). More so, there should be a drive toward responsible and ethical deployment of AI through the establishment of regulatory frameworks, standards, and guidelines (Ogwo et al., 2023; Quimba et al., 2023). Clear guidelines pertaining to data protection, algorithmic transparency, and accountability mechanisms ensure that public trust in the technology is safeguarded while reducing concerns in issues of privacy, bias, and even discrimination concerns (Rasheed et al., 2024; Santosh & Gaur, 2022).

Furthermore, there is a need for the development of appropriate initiatives for capacity building and skill development, which enable citizens, organizations, and policymakers to have the knowledge and skills to release AI's potential for sustainable development (Gupta et al., 2023; Kittichat, 2024). Training programs in data science, machine learning, and AI ethics enable stakeholders to effectively and responsibly operationalize AI technologies across the board (Mukherjee & Sarma, 2022; Rasheed et al., 2024). It could additionally bring about innovation, synergies, and common challenge solving related to adoption and governance of AI by furthering the collaboration and knowledge-sharing among stakeholders (Nyagadza et al., 2022; Sharma et al., 2024). Public-private partnerships, technology incubators, and innovation hubs could jointly develop AI-driven solutions for sustainable development in Thailand (Ogie et al., 2018; Rasheed et al., 2024).

Implications for Policy and Practice

The importance of the findings of the systematic review is for making policies, practice, and the processes of decision-making in Thailand (Ogie et al., 2018; Philbin et al., 2022). Policymakers and government agencies in the country should put in place supportive policy frameworks, regulatory mechanisms, and institutional structures that prioritize the responsible and ethical adoption of AI technologies (Nabi, 2019; Ohalete et al., 2023). Building a strong partnership

between industry, academia, and civil society in the development and implementation of AI governance frameworks, data protection laws, and ethical guidelines that are responsive to the Thai context (Thanyawatpornkul, 2021; Zhou et al., 2022).

Elsewhere, practitioners and stakeholders in all other sectors need to put AI technologies into application by alluring themselves into the challenges and opportunities in reference to sustainable development in Thailand (Gajić et al., 2024; Mhlanga et al., 2023; Taghikhah et al., 2022). This may be realized through piloting AI-driven solutions, conducting impact assessment, and tracking to what extent the country has done in the process of actualizing its sustainability aspirations in a manner that AI deployment translates into tangible and just outcomes for society at large (Brock & Von Wangenheim, 2019; Rane et al., 2023b).

Future Research Directions

In total, though the systematic review created knowledge on the current status of AI adoption and what it bodes for sustainable development in Thailand, there remain some areas that are needed to be inquired into further (Hong & Xiao, 2024; Mhlanga et al., 2023). In the future, the impacts of AI adoption on the socioeconomy, the ethical and social implications of AI-driven technologies, and the effectiveness of the interventions and initiatives in policies and capacity building that promote responsible AI deployment should be tested (Jaiswal & Arun, 2021).

Further, AI technologies exist in many interdisciplinary research areas that could be utilized to address the complex challenges and opportunities in the Thai context (Nwankwo & Ukhurebor, 2021; Srivastava & Maity, 2023). It also follows that interdisciplinary research within the team of researchers, policymakers, practitioners, and other stakeholders will bring about innovative solutions and insights to further sustainable development in Thailand and elsewhere (Ohalete et al., 2023; Saba & Monkam, 2024; Thanyawatpornkul et al., 2016).

CONCLUSION

This systematic review provides valuable insight into the cross-cutting landscape of applications in AI and their implications for sustainable development in Thailand. At a macro level, these indicate the immense opportunities that AI technologies provide in a wide array of sectors: agriculture, health, governance, and urban development, among others, to realize the objectives of sustainable development. AI-driven innovation provides a way to achieve higher efficiency, productivity, and inclusivity, which underpins the major environmental, social, economic, and economic challenges of the country. However, within these opportunities lie crucial challenges and limitations that have been brought out, which need to be addressed in order to maximize the positive impacts of AI technologies on sustainable development. The most important barriers to the responsible and equitable adoption of AI technologies in Thailand are the digital divide, ethical concerns, gaps in regulation, and capacity constraints. Responding to the set of challenges that confront us will take a focused effort from policymakers, practitioners, and

stakeholders in the development of strong policy frameworks, mechanisms for regulation, and initiatives for the capacity development of how AI adoption can be steered by the objectives and principles of sustainable development. Furthermore, this review highlights that this collaborative knowledge-sharing between stakeholders is aimed at inclusive access, responsible deployment, and ethical use of AI technologies. All this is possible with Thailand working collectively toward the transformative potential of AI in driving socioeconomic development and improvement of governance processes and the quality of life of its citizens. The study results are followed by a set of recommendations and strategies for future research and policy action. The recommendations range from prioritizing inclusive access to AI technologies, building regulatory frameworks and governance mechanisms, enhancing capacity building programs, and fostering interdisciplinary collaboration.

In general, this systematic review contributes toward understanding the opportunities and challenges in AI adoption for supporting sustainable development in Thailand, where opportunities sometimes seem to equal the number of challenges. By effectively addressing these challenges and harnessing its full potential, Thailand will be able to expedite its pace of progress in the direction of achieving its sustainable development agenda and building a more resilient, equitable, and prosperous society for future generations.

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