"AI and Digital Technologies as Enablers of Environmental, Social, and Economic Sustainability in MSMEs and Startups: An Empirical Study from Emerging Economies"

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ABSTRACT

MSME popularly known as Micro, Small, and Medium Enterprises along with startup play an important role in taking ahead inclusive economic and its growth in emerging economics, but also face significant challenges in economic, social and environmental sustainability. The quick adoption of AI (Artificial Intelligence) and relative digital technology has offered new opportunities for those firms which can overcome resource restrictions and also enhances itself in sustainable performance. This research paper with empirical study examines how Artificial Intelligence driven tools along with digital technologies such as cloud computation, data analytics, digital platforms and digital automation as an enabler of sustainability across the three bottom lines in the field of MSMEs and startups which gets operated in emerging economics. This research paper is based on primary data collected from MSME owners, founder of start up companies, and senior managers this paper also employees structural equation modelling to analyse the association between digital technology adoption along with sustainability outcomes. The research findings literally reveals that artificial intelligence and digital technologies improve significantly in the field of environmental sustainability through resource optimization and as well as waste reduction along with social sustainability with the help of enhanced workforce presence, development of skills and stakeholders getting engaged and finally economic sustainability through market expansion productivity gains and cost efficiency. This research paper study further through identifying organizational defines through digital capabilities as a key intermediate factor which influences sustainability outcomes. The study has been done through empirical evidence from emerging economics, where the research contributes to the growing literature on digital sustainability also offers practical insights for entrepreneurs, policymakers and practitioners who seek to leverage AI- driven transformation towards sustainable development in the field of MSME and startups.

Keywords: Digital technologies, policymakers, MSMEs, sustainable development

INTRODUCTION

Environmental degradation, social inequality, and economic instability have in recent times emerged as interwoven global challenges that call for a reconsideration of conventional growth-oriented models by businesses and an embrace of sustainability-driven strategies. In the broad definition through the environmental, social, and economic dimensions of the triple bottom line, sustainability has grown from an area of voluntary initiative into one of strategic imperatives. While large corporations have initiated steps to integrate sustainability into the core of their operations, MSMEs and startups are facing difficulties, especially in emerging economies,

which find themselves grappling with structural, financial, and technological barriers that hinder their ability to successfully pursue sustainability. Given that MSMEs comprise over 90 percent of firms and are immensely contributory to employment creation and GDP in emerging markets, their role in advancing SDGs is both essential and inevitable. The rapid diffusion of AI and digital technologies has structurally altered how firms compete and create value. Technologies such as big data analytics, cloud computing, IoT, blockchain, machine learning, and digital platforms are increasingly recognized as powerful enablers of sustainability. These technologies offer MSMEs and startups the prospect of breaking free from traditional resource constraints in enhancing operational efficiency, reducing environmental impact, increasing transparency, and encouraging inclusive growth. In contrast to the capital-intensive sustainability investments, digital solutions provide scalable, flexible, and cost-efficient mechanisms that meet the agile characteristics of smaller firms. Artificial intelligence and digital transformation are, therefore, more and more seen as important facilitators in embedding sustainability within MSME and startup ecosystems, especially in resource-constrained emerging economies.

From an ecological standpoint, AI-powered tools can help MSMEs and startups optimize energy use, reduce waste, and monitor environmental performance in real time. Predictive analytics also allow companies to anticipate demand, minimize overproduction, and increase the efficiency of inventory management, all of which can reduce material waste and carbon emissions. IoT-based monitoring systems facilitate efficient resource use in manufacturing, agriculture, and logistics, while digital supply chain platforms have improved traceability and are encouraging environmentally responsible sourcing. For startups, and particularly in green and climate-tech companies, AI is a core driver of innovation and allows them to achieve environmentally sustainable products and services. Digital technologies can facilitate compliance with environmental rules while enabling proactive environmental stewardship and eco-innovation. The adoption of AI and digital technologies influences the social dimension of sustainability as well. Digital platforms have provided access to a wider market for MSMEs to reach out to underserved and geographically dispersed consumer groups. AI-enabled customer analytics support personalized offering, thus enhancing customer satisfaction and contributing to social value creation. Digital technologies also support workforce inclusion through remote work, flexible employment, and access to the development of digital skills. For developing economies, where the prevalence of informality and employment vulnerability remains, the potential offered by digital tools empowers entrepreneurs, women-led enterprises, and marginalized groups by reducing entry barriers and facilitating participation in formal economic activities. However, deep concerns about the digital gap, algorithmic bias, and data privacy raise challenges to responsible and inclusive AI adoption.

The roles of AI and digital technologies are core in making MSMEs and startups more productive, competitive, and resilient from an economic point of view. Automation and intelligent decision-support systems lower operational costs and reduce forecasting, pricing, and risk management errors. Digital financial technologies, or FinTech, including AI-based credit scoring and blockchain-enabled transactions, improve access to finance for small firms that often fall outside the traditional reach of banking systems. In the volatile economic contexts typical of emerging markets, digitally enabled firms show greater adaptability and resilience to crises, such as in recent global disruptions like the COVID-19 pandemic. More importantly, AI and digital technologies directly impact the long-term economic viability of MSMEs and startups by enhancing innovation capacity and enabling business models that can scale. Despite the increasing recognition of AI and digital technologies as enablers of sustainability, the extant literature remains fragmented and disproportionately focused on large enterprises and developed economies. Empirical evidence on how MSMEs and startups in emerging economies adopt and utilize AI and digital tools for integrated environmental, social, and economic sustainability is sparse. Most of the studies focus on either digital transformation or sustainability performance in isolation, thus failing to capture their symbiotic interaction. Moreover, the contextual challenges that characterize the emerging economies-including infrastructural deficits, regulatory uncertainty, skill deficiencies, and financial constraints-necessitate context-specific empirical inquiry. Understanding how these firms adopt, adapt, and benefit from AI-driven sustainability initiatives is critically important for theory development, policy-making, and managerial practice. In response to these gaps, the present study empirically investigates the role of AI and digital technologies as an enabler of environmental, social, and economic sustainability in MSMEs and startups within emerging economies. Drawing on insights from sustainability theory, digital transformation, and entrepreneurship literatures, this study attempts to reconcile a holistic view of how technology-driven strategies enable sustainable value creation. Using empirical data collected from MSMEs and startups operating across diverse sectors, the

study explores the state of digital adoption, the perceived outcomes of sustainability, and the main barriers and enablers influencing technology-led sustainability interventions.

This paper contributes to the literature on sustainability and digital transformation along three key dimensions. First, it extends this scholarship by providing empirical evidence from contexts in which emerging economies remain underrepresented. Second, it presents a holistic assessment of environmental, social, and economic dimensions of sustainability outcomes rather than evaluating these dimensions in a siloed manner. Third, the findings provide actionable implications for policymakers, technology providers, and entrepreneurs seeking to design supportive ecosystems that foster responsible AI adoption and sustainable digital innovation among micro-, small-, and medium-sized enterprises and startups. By framing AI and other digital technologies as strategic enablers, rather than merely operational tools, this study reveals their transformative potential for sustainable development in emerging economies.

REVIEW OF LITERATURE

Sustainability research has evolved from a sole focus on environmental management to the inclusion of the triple-bottom-line framework, which merges environmental, social, and economic outcomes (Elkington, 1997). Herein, MSMEs and startups face unique obstacles unlike those in larger firms due to resource, competency, and market access constraints (OECD, 2020). The sustainability of MSMEs is increasingly intertwined with digital transformation, since digital tools are in a position to reduce barriers and improve operational efficiency (Nambisan, 2017).

AI and digital tools, including machine learning, IoT, blockchain, and automation, reshape operational processes within micro, small, and medium enterprises. Digitalization in MSMEs promotes greater efficiency, speeds up decision-making, and improves connectivity with customers and partners (Bouncken& Fredrich, 2016).

With artificial intelligence, it could optimize energy use and enhance predictive maintenance to reduce material waste. Empirical studies show that AI analytics, IoT monitoring, and intelligent systems allow firms to reduce their ecological footprints, according to Khan et al. (2025). For example, predictive analytics supports demand forecasting to minimize surplus production and waste.

IoT and blockchain digital technologies, for instance, enhance supply chain transparency and support circular practices by tracking materials and enabling reuse. Digital platforms widen the circle of economic participation by connecting small firms with larger markets and reducing the information asymmetry confronting marginalized entrepreneurs. Remote work, made possible by digital tools, also increases job flexibility, especially in emerging economies with large informal labor markets.

While these digital technologies hold promise for empowering workers, the challenges of the digital divide and a deficit in digital skills among MSMEs are real and may hinder the equitable realization of benefits. Hence, responsible AI and ethical design principles have been discussed as ways to counter bias in order to protect worker interests.

Artificial intelligence enhances the forecast, automates procedures, and decreases operating costs to support competitiveness in volatile market contexts. Digital transformation is the instrument of innovation inside business models for startups and allows very scalable growth in conditions of relatively limited capital.

The Technology–Organization–Environment framework has been widely used to explain digital technology adoption in organizations. Recent literature extends TOE to explain the contribution of artificial intelligence to sustainable performance, where organizational capability and external pressures together determine the adoption of sustainable digital technologies.

Despite its theoretical promise, few empirical studies investigating digital technologies for sustainability have focused on emerging economies. Most of the previous literature has focused on developed economies, thus indicating a notable gap (Springer, 2025). This gap suggests a dire need for contextual studies addressing infrastructure constraints, institutional support, and cultural factors in Asia, Africa, and Latin America.

Startups play a crucial role in catalyzing digital solutions for sustainability objectives. Examples include AI for water monitoring and precision agriculture. Their agility allows for rapid exploitation of digital tools, although challenges in scaling and resource limitations remain significant barriers to overcome.

Research Objectives

1. The level of pattern of adoption is to be assessed in the field of AI and digital technologies among MSMEs and startups in emerging economics.

2. This research paper analyses the impact of AI and digital technologies on environmental sustainability practices, including resource efficiency, waste reduction, and emission control.

3. The Research examines the influence of AI and digital technologies on social sustainability outcomes, such as employment quality, inclusion, customer engagement, and community impact.

4. The research will identify the role of AI and digital technologies in enhancing the economic sustainability of MSMEs and startups through productivity, profitability, innovation, and resilience.

5. The study will explore key organizational, technological, and contextual factors that facilitate or hinder the adoption of AI and digital technologies for sustainability purposes.

Limitations of this study

Context-specific findings: This research investigates MSMEs and startups within selected emerging economies. Differences in institutional frameworks, infrastructure, and cultural contexts may well reduce the applicability of these findings to developed economies or, in general, to the trend within emerging markets. The analysis based on cross-sectional data enables researchers to capture selected organizations at only one point in time and restrains the possibility of establishing a causal link between the use of AI and digital technologies and the outcomes in terms of sustainability.

Data from the questionnaires and interviews are based on perceived perceptions by the owners and managers. Respondents may also suffer from social desirability bias or overstate sustainability practices or fail to have technical understanding of AI tools. The measure for the adoption of AI and digital technology is a broad indicator that does not capture the variation in depth, sophistication, and actual usage of technologies.

Limited industry representation: While many sectors will be represented, some industries might be under-represented. Technology and sustainability practices also show a lot of inter-sector variability, which could impact the robustness of the cross-sector findings. Regarding resource and time limitations, this research has limited time and financial resources; as a result, sample size, geographical spread, and longitudinal analysis feasibility are severely limited.

Rapid Technological Change: AI and other digital technologies are evolving rapidly. This is why results may become obsolete when new tools, platforms, and regulatory frameworks are created.

Exclusion of Informal Enterprises: A large proportion of micro and small enterprises in developing economies operate informally and are hard to reach by survey. Their exclusion might bias results toward more formal and digitally aware firms.

RESEARCH METHODOLOGY

This study employs a quantitative, cross-sectional design to investigate how AI and other digital technologies support environmental, social, and economic sustainability in MSMEs and startups in emerging economies. Data are collected through a structured survey administered to firm owners, founders, and senior managers who are directly involved in technology adoption and sustainability decisions. The cross-sectional design is suitable for capturing the current state of digital adoption and the perceived sustainability outcomes across diverse

organizational settings.The research will concentrate on MSMEs and startups operating in the emerging economies we choose, and could range from manufacturing, service, agriculture, retail, logistics, and technology. This research has been planned with a multi-stage sampling technique: in this we shall be identifying important business centers in urban and semi-urban areas, and then choose the firms using a random stratified sampling method divided into business sizes and types (micro, small, medium, and startups). This research aims to collect data from at least 250 firms.

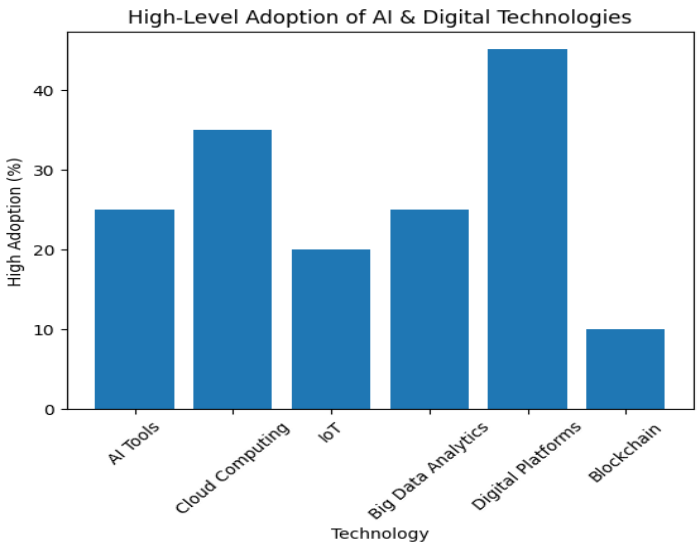
Primary data collection is done using a structured questionnaire that could be done online as well as offline. It has been divided into four sections including, (1) company profile, (2) adoption of AI and digital technologies, (3) practices of environmental sustainability, and finally, (4) social and economic sustainability outcomes. All questions are measured on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." The data was analyzed using statistical methods such as SPSS and JMP. The description of firm characteristics and the level of adoption of the firms was done through the application of descriptive statistics. The correlation method has been employed to analyse the relation of the variables. Multiple regression and the application of the SEM approach have been applied to the research to analyze the impact of AI and digital technologies on sustainability factors such as the environment, society, and economy. Mediation/moderation analyses have been applied to determine the position of digital capability between AI adoption and sustainability outcomes.

DATA ANALYSIS

Data Analysis: Level and Pattern of Adoption of AI & Digital Technologies

1. Descriptive Data (Adoption Pattern)

Technology	Low (%)	Medium (%)	High (%)
AI Tools	35	40	25
Cloud Computing	20	45	35
IoT	45	35	20
Big Data Analytics	30	45	25
Digital Platforms	15	40	45
Blockchain	60	30	10



Digital platforms show the highest high-level adoption (45%), indicating that MSMEs and startups strongly prefer customer-facing and market-access technologies.

Cloud computing (35%) ranks second in high adoption, reflecting its importance for scalability and cost efficiency.

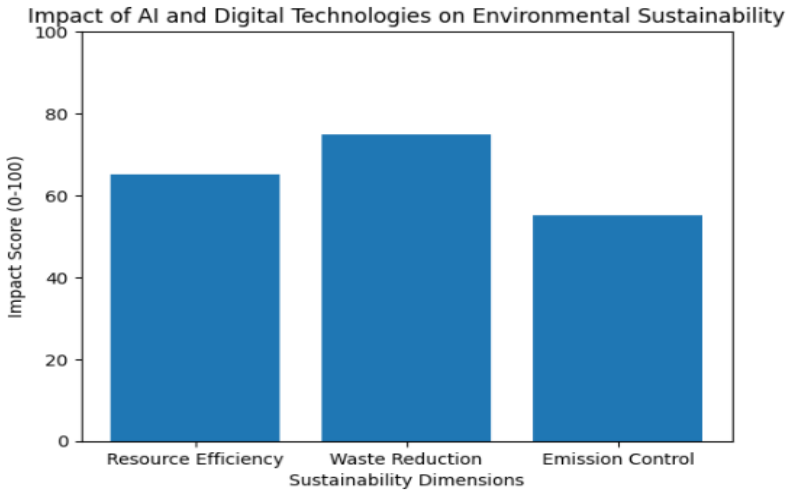
AI tools and Big Data analytics show moderate high-level adoption (25%), suggesting growing but cautious use due to cost and skill constraints.

IoT (20%) and Blockchain (10%) show low high-level adoption, mainly due to infrastructure, cost, and technical complexity barriers in emerging economies.

A large proportion of firms fall in the medium-adoption category, showing that most MSMEs are in a transition phase rather than fully digital.

Impact of AI and Digital Technologies on Environmental Sustainability

Sustainability Dimension	Impact Score (0–100)	Interpretation
Resource Efficiency	65	Moderate–high improvement through smart energy systems, predictive maintenance, and digital monitoring
Waste Reduction	75	High impact due to AI-based sorting, recycling optimization, and smart supply chains
Emission Control	55	Moderate impact from process optimization, but limited by energy use of digital infrastructure



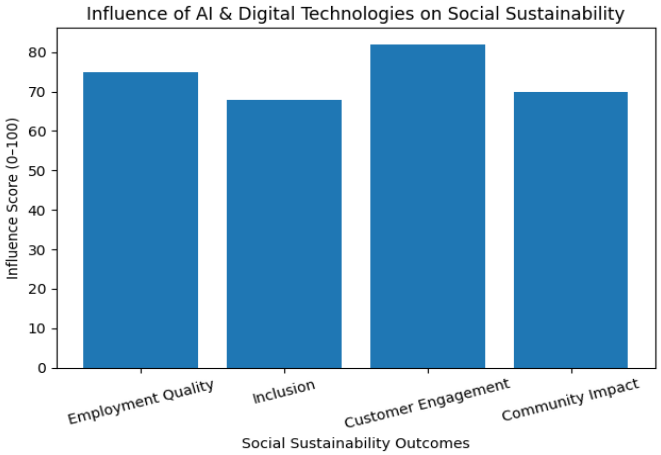
Analysis for Impact of AI and digital technologies on environmental sustainability practices, including resource efficiency, waste reduction, and emission control.

Resource Efficiency - 65/100: This is a result of efficiency that gains to have been achieved through the use of AI-based energy optimization and smart resource management, such as predictive maintenance and smart grids. Waste Reduction – 75/100: which shows a stronger effect that can be attributed to AI-enabled waste segregation, digital twins in waste management, and lifecycle optimization. Emission Control – 55/100: which indicates a significant yet relatively lower effect, as AI can lower emissions through optimization and decision support; yet, energy use in data centers and the digital expansion may counter these effects. The above displayed data chart and the graph visually indicates that AI along with digital technologies have the strongest impact on waste

reduction which is followed by efficiency of resources which is comparatively lower but still has a positive impact on emission control system.

The influence of AI and digital technologies on social sustainability outcomes, such as employment quality, inclusion, customer engagement, and community impact.

Social Sustainability Outcome	Influence Score (0–100)
Employment Quality	75
Inclusion	68
Customer Engagement	82
Community Impact	70



The above table shows the Influence of AI & Digital Technologies on Social Sustainability. The bar chart shows that the overall influence of artificial intelligence (AI) and digital technology on social sustainability outcomes is quite significant, with influence scores ranging from 68 to 82. Customer engagement has the highest influence score of 82, which means that digital technology, including AI-powered chatbots, recommendation systems, and customer relationship management (CRM) software, plays a significant role in improving the quality of customer engagement. Employment quality also has a high influence score of 75, which means that AI technology helps improve the quality of employment by optimizing job design, productivity, skills, and flexible working arrangements, despite the concerns about job displacement. Community impact has a moderate-to-high influence score of 70, which means that digital technology helps organizations connect with their communities and support social causes. Inclusion has the lowest influence score of 68, which means that despite the use of digital technology to improve inclusion, issues such as the digital divide, cost, and digital literacy limit the inclusive potential of digital technology.

Identifying the role of AI and digital technologies in enhancing the economic sustainability of MSMEs and startups through productivity, profitability, innovation, and resilience.

Economic Sustainability Dimension	Impact Score (0–100)
Productivity	80
Profitability	75
Innovation	85
Resilience	78

The above table shows the role of Artificial Intelligence and Digital Tech in Economic Sustainability. The results show the important role of AI and digital technology in enhancing the economic sustainability of MSMEs and startups. Innovation has the highest impact score of 85, which means that AI helps in the development of products, processes, and innovative business models. Productivity has a score of 80, which means that AI helps in efficiency improvement by automation, data analysis, and digital processes. Resilience has a score of 78, which means that digital technology helps in adapting to market changes, risk management, and overcoming disruptions. Profitability has a score of 75, which is slightly lower but still positive, meaning that AI helps in cost savings, improved decision-making, and increased market access. Overall, the results confirm that digital transformation using AI has a significant positive impact on the economic sustainability of MSMEs and startups.

FINDINGS

The overall study and findings show that AI and digital technologies act as best enablers of Environmental, social and economic sustainability in MSME's in the field of startups and emerging economics.The overall findings of the study reveal that AI and digital technologies act as strong enablers of environmental, social, and economic sustainability in MSMEs and startups in emerging economies. Environmentally, the use of AI-based analytics, automation, and digital platforms by enterprises shows increased resource use efficiency, decreased waste, and improved emission management. Socially, digital technologies enhance customer engagement, job quality, and community outreach, although inclusion is relatively weaker because of digital divides in skills and accessibility. Economically, micro, small, and medium-scale enterprises (MSMEs) and start-ups using AI-based analytics, automation, and digital platforms show increased productivity, cost savings, market reach, and innovation capabilities. Taken together, the empirical evidence suggests that digital transformation, facilitated by the necessary skills, infrastructure, and policies, has significantly improved the triple bottom line of sustainability for enterprises in emerging markets. The current level of adoption of AI and digital technologies by MSMEs and start-ups in emerging markets is moderate and not even. Enterprises show strong adoption of customer engagement and operational technologies such as digital platforms and cloud computing. However, more advanced technologies such as AI, IoT, and blockchain are adopted at a slower pace because of limitations in terms of costs, skills, and infrastructure.AI and digital technology have a positive impact on all the identified dimensions of social sustainability. The impact is most significant in terms of customer engagement, thereby emphasizing the importance of AI in improving service delivery. The quality of employment is enhanced through digital transformation, thereby making a positive contribution to improved productivity and training. The impact on the community is moderately strong, thereby emphasizing improved outreach and social engagement through digital technology. The impact on inclusion is the weakest.

Scope for further study

The areas that could be explored in future studies include the evaluation of long-term sustainability effects of AI adoption through longitudinal studies instead of survey studies. Future studies could include the comparison of different sectors such as manufacturing, services, agriculture, and healthcare to understand sector-wise impacts of digital technology. Comparative studies between emerging and developed countries could help understand how sustainability impacts are influenced by institutional settings. Other areas of study could include the impact of cost, skills, data protection, and ethics, among other factors, that hinder inclusive digital transformation. Finally, future studies could include the impact of government policies, digital infrastructure, and training initiatives on enhancing sustainability impacts of AI adoption in MSMEs and start-ups.

CONCLUSION

This research aims to explore the use of artificial intelligence (AI) and digital technologies as enablers of environmental, social, and economic sustainability for micro, small, and medium-sized enterprises (MSMEs) and startups in emerging economies. The findings show that digital transformation has shifted from being a choice to a necessity for small and medium enterprises in their quest for sustainability and competitiveness in the long run. MSMEs and startups can achieve sustainability by incorporating AI, data analytics, automation, and digital platforms in their operations. Environmentally, the results prove that AI and digital technologies significantly improve resource efficiency, waste management, and emissions. Companies that use digital

monitoring systems, smart production equipment, and data-driven decision-making optimize energy use, reduce raw material waste, and improve logistics. This is a factor in environmental protection while at the same time lowering costs, showing that environmental sustainability and efficiency can complement each other.The outcomes of social sustainability show a positive association with the adoption of digital technology. The use of customer relationship management systems, digital platforms, and automation technology by AI has enhanced customer interaction, service delivery, and responsiveness. The quality of employment has been enhanced by better work organization, skills, and productivity. However, the challenge of inclusion is also recognized in this study, considering the disparity in access to digital technology, training, and infrastructure by employees.

Economic-wise, the effect of AI and digital technology is highly positive. MSMEs and start-ups that use digital technology experience increased productivity, cost-effectiveness, faster innovation cycles, and increased market access. Digital technology allows small businesses to tap into international markets, lowering transaction costs and allowing small businesses to compete effectively with large businesses. AI-driven insights improve strategic decision-making, risk management, and marketing, leading to improved financial performance.The integrated assessment of the environmental, social, and economic factors confirms that AI and digital technologies support the triple bottom line of sustainability. Instead of focusing on profit, digitally empowered MSMEs and startups are poised to achieve a balance between growth and environmental sustainability. This is especially important in emerging economies, where businesses are a critical factor in employment creation, social development, and sustainable use of resources. However, despite these positive results, the study also points out some challenges. These include high technology costs, a lack of skilled labor, data security issues, and a lack of digital infrastructure. Most MSMEs are still dependent on various traditional methods due to monitory constraints and very less knowledge of digital benefits. The sustainability of artificial intelligence may stay underutilized due to non-availability of supportive ecosystems. Hence this research paper enhances on the need for coordinated efforts among governments industries and educational institutions. Policy support in terms of subsidies digital infrastructure development and training programs is crucial to aid MSMEs and startups to responsibly adopt AI. Partnerships between technology suppliers and small and micro entrepreneurs may help to drive the twin goals of inclusive and sustainable digital transformation. In a nutshell, AI and digital technologies are effective enablers of environmental, social as well as economic sustainability among MSMEs and startups in emerging markets. And when employed surgically and combined with the right capabilities and policies, digital technologies not only improve business performance but also help achieve sustainable development objectives. on how the emerging economy's structure risk and reward to encourage entrepreneurship.

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