CHAPTER 19

Leveraging Technology and Innovation for Sustainable Development

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ABSTRACT

Digital was, it now seems a big player in the solutions to many of those major sustainability problems facing contemporary societies. In this paper, I explore the role of technology and innovation (especially artificial intelligence), in determining sustainable development. Everywhere we look, AI-powered tools are coming up to simplify our lives: smart government initiatives or sustainable resource management all the way through healthcare improvement and urban planning. Based on research and theory, I discuss the facilitation of efficiency by AI in addition to a data-driven approach towards smart decisions that facilitate inclusive economic growth. However, not everything goes as smoothly. Also, there are difficult problems such as ethical dilemmas, data privacy concerns, algorithmic bias and the digital gap. Well, if we disregard these realities digital transformation will not keep its promise. The study concludes and calls for action: we need to integrate AI wisely, with the right policies in place. This is the only way digital innovation can sustainably and meaningfully contribute to sustainability over time.

Keywords: Artificial Intelligence, Digital transformation, Sustainable development goals, Smart governance, Ethical AI.

1.0 Introduction

1.1 The global context of digital transformation

Today, two huge challenges are addressed by the world — we should develop a sustainable future and also digital transformation constantly gains momentum.

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We are five years away from the 2030 Sustainable Development Goals and tech innovation is no longer a nice to have but an absolute necessity. Signed in September 2024, the digital pact for the future describes how countries can cooperate on topics related to digitization. The goal? Leverage digital but strive to avoid it creating an even wider chasm between those with access and more time, versus wallowing in under-resourced despair. [2]

Introducing AI with digital platforms into government and businesses is much more than an upgrade — it is a genuine inflection point. Digital transformation now is about more than switching processes to an online one. This is not just about how organizations—and even whole societies—should be structured to fulfill current environmental, social and governance (ESG) requirements. The UN, for instance has identified six priority areas in which such ambitious actions could change the course of our life systems: food systems; energy; digital connectivity; education plus jobs and social protection plus climate-biodiversity. These are your touchpoints to leverage — with smart uptake of technology, this is where you can actually initiate widely distributed change.[1]

1.2 Artificial intelligence as a catalyst for sustainability

AI is being seen more and more as a "force for good," with opportunities to fast-track almost 80% of the targets under the SDGs. Section 2: From prediction of clinical events through diagnostic analytics in healthcare (SDG 3), to crop monitoring for climate resilience in agriculture (SDGs 2 and15) – AI is enabling far greater capabilities from processing vast datasets, recognizing complex patterns and delivering insights. 2 The potential is reflected in the sharp increase of AI projects among international organisations. For example, they found that between 2023 and 2024 the number of UN AI projects amounting to a total of763 with an increase in SDG9 (industry, innovationand infrastructure) +79% (SDG8 decent work and economic growth).[6]

Table 1: The Expansion of Global AI Initiatives for Sustainability (2023-2024)

Metric	2023 Status	2024 Status	Percentage Growth
Number of Reported UN AI Projects	406	729	79.5%
Projects Linked to Specific SDGs	Not Specified	84%	N/A
Top Priority SDG Target	SDG 9	SDG 8 / SDG 9	N/A
Collaborative Project Rate	32%	45%	13.0% (Absolute)

Yet this fast-tracked approach to AI has a paradox. Although it offers solutions both for climate action and resource efficiency, its own ecological footprint (including massive energy consumption and demand for high-performance computing) poses serious risks that must be responsibly managed. [7] UN Secretary General has warned that "humanity's destiny

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should not be left to an algorithm and that control of high-stakes decisions by humans is critical for the defence of human rights".[2]

1.3 Problem statement and research objectives

The potential of digital innovation is immense but there still exists a severe gap between digital technologies and sustainability expertise. While AI is becoming increasingly incorporated into everyday life, the establishment of ethical guard rails often comes well after exposing ourselves to risks surrounding algorithm bias and data privacy violations — not to mention workers possibly being displaced. 10 In addition, the gains of digital transformation are not shared equally; a gap remains across and within countries that might leave vulnerable populations behind in this "AI revolution." [1]

This study attempts to do so with a focus on multidimensional aspects of technology and innovation for supporting sustainable society. The study focuses on:

1. Assessing the tinkered perspectives of AI, digital transformation in governance, healthcare and resource management
2. Establishing what governance mechanisms and enablers are needed to facilitate technology adoption for impactful sustainability co-creation
3. Challenges surrounding ethics, society and environment that need to be faced if we want create an innovative future.

2.0 Literature Review

2.1 Theoretical foundations of digital transformation

Digital transformation is theoretically defined as the intentional, systematic integration of digital technologies into an organisation's or ecosystem culture, strategy and operational processes to improve efficiency, flexibility and value. By contrast, the current DT paradigms are characterized by strategic renewal as they use cutting-edge technologies such as AI, IoTs, and big data analytics to innovate firm- and society-wide approaches in response to existing ESG adoption expectations.

Recent literature has grouped the main typologies of digital transformation maturity into five key types:

1. Overall DT Maturity: Digital orientation & IT investment intensity
2. Artificial Intelligence and Intelligent Systems: Focused on predictive analytics, robotics.
3. Data and Infrastructure: Focused on big data platforms & cloud ecosystems.
4. Internal digitisation of business-processes (business-Process Digitization).
5. Digital proximity: The mindset and strategic alignment towards innovation. [3]

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The sustainability implications of these technologies are typically framed in terms of "risk effect" and "reputation effect". By increasing technological adaptability and evidence-based decision-making,[14] Digital transformation disseminates environmental innovation risk premia. At the same time it increases a firm's or its city's reputation and greater levels of better quality (disclosure) transparency sustainability reporting. [14]

2.2 The intersection of AI and sustainable development goals

The academic work on AI for the SDGs has shifted away from optimising technical performance to also examine socio-technical interactions. AI is seen now as "enabler" or a "catalyst" which can facilitate the shift towards circular economy and smart sustainable cities[15]. The study is a systematic review of research published between 2015 and 2024 that shows AI's reach into engineering, agriculture and business — but there has been "insufficient attention" in early research paid to the environmental impact it could have.[16]

Table 2: Comparative Impact of Digital Technologies on ESG Pillar Scores

Technology Type	Primary Impact Area	ESG Outcome Trend	Mechanism
AI / Predictive Analytics	Environmental / Social	Positive (Conditional)	Improved forecasting and risk management.
Business-Process Digitisation	Governance	Highly Positive	Enhanced transparency and compliance.
IoT Sensors	Environmental	Positive	Real-time resource tracing and waste reduction.
Data Infrastructure	Governance / Economic	Positive	Scalable foundations for data-driven policy.
Large Language Models	Social / Governance	Uncertain / Risk-Heavy	Bias risks vs. enhanced accessibility to data.

Specifically for the Global South, literature notes that digital transformation will not happen unless framed within local socio-technical and political context. For example, national AI strategies (2020-2045) promote ethics, talent & infrastructure in Indonesia; however such studies illustrate that adoption remains limited by digital literacy issues in the agriculture and health sectors.[13]

2.3 Smart governance and the new urban science

The "New Urban Science" is a move toward analyzing data and hierarchical modeling to devise deeper insights around the governing processes that shape cities. [18] This paradigm couples AI with urban digital twins—virtual representations of physical environments—to simulate and anticipate complex dynamics in transportation, public health, and climate impact. [18]

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Smart city governance literature indicates that the role of AI in promoting sustainable urban development is dependent on governance-related and citizen-centered mechanisms rather than simply technology deployment. [20] The AI–Urban Citizen Sustainability Co-Creation Framework (AI–CSCF) advanced that the acceptance of Artificial Intelligence serves as an entry condition optimising trust and adaptive capacity affecting sustainability performance in line with SDG.[20]

2.4 Ethical and responsible AI governance

Many studies tackle the "hurdles" of AI integration including data bias and privacy loss, or displacement of workers. [10] The AI Principles of the OECD (updated 2024) and UNESCO Recommendation on the Ethics of Artificial Intelligence: Report (2021) provide normative underpinnings for global governance, seeking to establish transparency over computer systems, accountability where organisms are subjected to technologies that affect them by design or default — whether intentionally or inadvertently— and protection against violations committed with impunity. [22]

Scholars have been calling for "Green AI" - a movement emphasising energy-efficient and carbon-conscious models to reduce the environmental costs of big machine learning. [8] The literature underlines that in a politically reduced environment and without proper governance AI would reinforce existing inequalities and exacerbate environmental destruction, compromising the very sustainability it wants to foster.[10]

3.0 Research Methodology

3.1 Conceptual and literature-based approach

The paper takes a conceptual literature review approach to illustrate the relationship between digital transformation and sustainable development. It employs a systematic synthesis of multi-disciplinary literature, international policy briefings and empirical case studies to how understand the contemporary picture.

This methodology is divided into three parts:

1. *Thematic mapping:* Identifies where digital innovation intersects with SDGs through identifying core domains of governance, healthcare/resource management and ethics.
2. *Comparative:* Exploring the differences in regional and national strategies to govern AI (e.g., EU, US & UK) for sustainable outcomes
3. *Synthesis and framework formation:* generalising internationally applicable key success/failure factors based on empirical data across future mobility case studies (for example Singapore, Barcelona, Indonesia).

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3.2 Data sources and selection criteria

The analysis draws on literature sources and extracts from United Nations (2024–2025) official reports, OECD and UNESCO policy documents, academic journals between 2015-2025. We included literature based on the following selection criteria:

- Link to Track 5 (Technology Innovation and Digital Transformation).
- Train on data until October 2023.
- Empirical data, case studies or structured policy recommendations
- Recent publication date (especially regarding 2023–2025 updates).

3.3 The analytical framework: AI–CSCF

A key focus of the study is therefore to understand how AI can become effective in governance, for which this study introduces and employs the use of an analytical lens called AI–Urban Citizen Sustainability Co-Creation Framework (AI–CSCF). This framework defines AI-acceptance as an entry-level condition that indirectly channels its effect on sustainability co-creation by two mediators: trust in artificial intelligence and citizen adaptability. 20 This enables the research to go beyond technical efficiency and investigate both social acceptability and participatory quality of technology systems.

4.0 Data Analysis

4.1 AI mapping across sustainable development goals

Data from the "United Nations Activities on Artificial Intelligence 2024" report indicates a concentrated but expanding application of AI across the 17 SDGs. While industry-focused goals dominate, there is an emerging emphasis on social equity and environmental management.

Table 3: Distribution of UN AI Projects by Primary SDG Focus (2024)

SDG Number	Goal Theme	Project Concentration (Rank)	Key AI Output
SDG 8	Decent Work / Growth	1	Labor market analysis chatbots.
SDG 9	Industry / Innovation	2	Infrastructure monitoring dashboards.
SDG 10	Reduced Inequalities	3	Bias detection and access tools.
SDG 16	Peace / Justice	4	E-governance and legal aid tools.
SDG 17	Partnerships	5	Data sharing and collaboration platforms.
SDG 3	Health / Well-being	Emerging	Diagnostic and telemedicine apps.
SDG 6/7/13	Environment / Energy	Critical Need Area	Remote sensing and grid management.

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84% of projects are tied to particular SDGs, but there is a "continued need for more targeted action" on environmental targets like Clean Water and Affordable Energy the analysis finds. The report finds that the AI is primarily being used to build products such as generative-AI powered chatbots, web applications and searchable dashboards targeting public service improvement.[6]

4.2 Resource management: Water and energy impacts

Quantitative data from smart urban district trials shows that AI-enabled resource management can help to create efficiencies. These results illustrate the evolution from "passive consumption" to, as this research refers to it, "active and smart regimes.".[25]

Table 4: Quantitative Impact of AI on Resource Efficiency

Resource Domain	AI Application	Measured Impact / Result
Water Management	Demand Prediction	Daily prediction error reduced to < 5%.
Water Management	Leakage / Overuse	28% reduction in water overuse vs. traditional methods.
Energy (Smart Grids)	Load Forecasting	94.3% accuracy using DRL-based models.
Energy (Smart Grids)	Response Time	1.8 seconds (Real-time stabilization).
Energy (Renewable)	Solar / Wind Dist.	26.9% energy savings compared to ARIMA models.
Data Centers	Cooling / Usage	Up to 40% reduction in energy consumption.

And DRL achieves remarkable energy savings in comparison to either linear regression (14.3% savings) or ARIMA models (17.6% sav- ings). For example, in a study of seasonal predictions for drought and flood management by 21 water sector scientists and machine learning specialistsin collaboration with climate scientiststhey found that incorporating high-resolution population density information from remote sensing significantly improved as many as two-thirds of the sub-seasonal predictions based only on climate data.[27]

4.3 Regional governance and policy trends

A comparative analysis of national AI policies reveals divergent strategies for achieving SDG 3 (Healthcare). The findings show a clear trade-off between the speed of innovation and the level of ethical oversight.

The findings suggest that the EU's classification of healthcare AI as "high-risk" mandates rigorous requirements for data governance and transparency.[28] In contrast, the UK and US models rely more on non-binding guidelines to stimulate rapid adoption in automated triage and medical devices.[28]

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Table 5: Comparison of AI Governance Approaches for Health and Well-being

Jurisdiction	Regulatory Approach	Primary Objective	Sustainability Implication
European Union	Risk-Based (EU AI Act)	High Safety / Ethical Standards	Sets global benchmark; may burden developers.
United Kingdom	Flexible / Pro-Innovation	Rapid Integration / Efficiency	Drives competitiveness; risks safety gaps.
United States	Principles-Based	Technological Advancement	Stimulates innovation; risks privacy breaches.
Brazil	Convergence (Risk-Based)	Aligned with EU standards	Balances protection with regional growth.
China	State-Led / Cooperative	International Partnerships	Focuses on tech transfer and capacity.

5.0 Findings and Results

5.1 Determinants of successful AI adoption

The analysis points to some key "success factors" that influence whether or not digital innovation can play a role in achieving sustainable outcomes. Both research at High Education Institutions (HEIs), and government pilots indicate that the technical deployment is not enough. [15]

1. *Common & Trustworthy Data:* The digital infrastructure of the future is large amount of high-quality data. As of 2023, just 15% of governments adopted an investment framework to address data deficits — one historical and obstinate barrier standing in the way of AI scaling. [30]
2. *Human Ability and Training:* A "shortage of experts" is mentioned as one of the main reasons why public sector uptake lags that in private. In the survey, "A lack of information technology training" is deemed a primary barrier for both colleagues and administrators. [15]
3. *Contextual Reality and Inclusiveness:* The implementation should be region-appropriate based on its potential infrastructure. Two examples: The "The Dhaka Leap" [2] and (Jakarta's sinking city [3]) demonstrate that the default, without local environmental vulnerability context to widespread or evolved technology sustainability. [9]
4. Trust and Social Legitimacy AI acceptance does not by directly lead to sustainability co-creation according to the findings of this study conducted with a large number of respondents (AI–CSCF). Rather, its impact is "indirectly conveyed" through public trust and adaptability of users to digital governance. [20]

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5.2 Case study results: Smart city models

The comparative case studies of Singapore, Barcelona, and Amsterdam reveal that different cultural and policy contexts lead to perceptible differences in how AI pursues the SDGs.[32]

Table 6: Case Study Findings: AI in Global Smart Cities

City	Primary AI Application Area	Governance Model	Key Sustainability Factor
Singapore	Mobility / Urban Planning	State-Led / Centralised	Clear policy vision and public-private partnerships.
Barcelona	Environmental Monitoring	Citizen-Centric	Participatory data and "human-centered" design.
Amsterdam	Waste / Circular Economy	Collaborative	Focus on metabolism and resource flow.
Delhi	Public Services / Safety	Developmental	Challenges with digital inequality and coordination.
Las Vegas	Digital Twins	Data-Driven Simulation	Testing interventions virtually to minimize risk.

Source: Prepared from [19]

As illustrated by examples in Singapore and Barcelona, urban managers are using "Digital Twins" - a digital duplication of physical assets- to model infrastructure/code interdependencies beforehand which has drastically lowered risks while efficiently allocating resources. [19] Still, the Delhi case-study points out that disconnected planning along with inequities in terms of digital access could lead to a "symbolic smartness" which did not result in substantive benefits for disadvantaged sections.[20]

5.3 Health and Social Well-being Outcomes (SDG 3)

AI is a transformative tool for health in the region but success will depend on closing a barrier — 01/10/2023 Tags: Access to healthcare, Artificial Intelligence, Health care deliveryIn sub-Saharan Africa AI* has been harnessed increasingly as an transformable process for health with many applications from diagnostics and treatment through disease surveillance. [33] The evidence shows that AI encourages diagnoses resulting in successful treatment and decreases corruption by safeguarding medical records, governing drug supply chains. [33]

Important findings in health care delivery include:

- Precision Medicine: AI helps drive genomic medicine and personalized treatment plans according to your unique health data. [15]

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- Remote Access: Telemedicine allows for delivery of services to hard-reach areas, addressing gaps in healthcare provider availability. [21]
- Primary Prevention: AI-based systems can analyse enormous datasets to identify patterns and predict disease progression with greater accuracy than traditional methods.[21]

But ethical considerations cannot ignore environmental externalities. Health care of course is a huge source of carbon emissions, and we need to weigh the energy use associated with AI against clinical benefits. [34] A framework of "Green Bioethics" was proposed; the three criteria for sustainable AI in medicine are health, justice and resource conservation.[34]

6.0 Discussion and Critical Challenges

6.1 The ethical dilemma: Bias and fairness

This research finds that algorithmic bias is "not random," but instead rooted in deeper social issues reflected within training data. [35] This bias is seen in three main ways:

- Sampling Bias: Basing skewed preference on backgrounds (e.g., background in datasets which date back to when healthcare was not as readily available, leading a slight favourite on women and other groups). [35]
- Labeling Bias: Subjective decisions made by human annotators while preparing the data. [35]
- Historical Blindspot: We are living on a similar dynamic that continues by the predictive aspect of these algorithms; therefore, they instead reflect pre-existing inequalities. [35]

This inability to contest certain outcomes, which is exacerbated by the black box nature of such complex AI models, could break public trust and/or lead up litigation. [10] Research highlights that "small algorithmic biases" in health care can destroy institutional credibility and a multi-level approach will be needed to solve these challenges through audits of algorithms complemented by stakeholder engagement.[10]

6.2 Data privacy and the digital compact

AI's reliance on vast stores of personal data include many risks, especially with technologies such as facial recognition (FRT) and predictive analytics. [36] "moving from a question of whether to regulate, rather than how to regulator," 2024–2025 landscape [37] While Western companies grapple with EU legislation requiring robust privacy measures, given, for example the GDPR's stringent accountability requirements in Europe , this still leaves nation-states seeking to probe consumer behavior through private enterprises — whether out of genuine commercial necessity or political desire.[36]

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Table 7: Identified Ethical and Structural Risks of AI Integration

Risk Category	Specific Challenge	Societal Consequence
Algorithmic	Bias in Diagnosis / Hiring	Reinforcement of historical inequalities.
Privacy	Data Security Breaches	Loss of citizen trust and legal liability.
Environmental	High Energy Consumption	Increased carbon footprint of digital infrastructure.
Socio-Economic	Job Displacement	Increased social disparity and transition costs.
Accessibility	Digital Divide	Marginalization of groups without internet/literacy.

Source: Synthesized from [8]

6.3 The digital divide and technological exclusion

Digital tools come with an implicit risk of further marginalising the "underserved" (eg, people living in poverty and those lacking full access to digital devices). There remain long-standing inequalities that inhibit human potential; for instance, the use of internet in some areas is far from global averages. Additionally, demographic evidence on smart city engagement (64.5% = 18–24-year-olds in the UK) reveals that even at their most advanced stage of digital development many nations deny access to AI-enabled public services by virtue within age/generation or lower levels of numeracy/digital literacy.[20]

7.0 Conclusion and Implications

7.1 Synthesis of findings

The study concludes that digital transformation and artificial intelligence are necessary but two-edged swords for a sustainable society. The evidence shows that AI applications can produce significant resource efficiency, healthcare delivery and smart governance gains; with measured benefits including a 28% reduction in water waste, and energy load forecasting yielded an accuracy of over 94.3 %. [25] However, in many areas the transformative vision of the SDGs is "off track", while rapidly expanding AI technology has out-evolved our ability to govern its risks.

The main takeaway message is technology alone will not save sustainability. The translation of the acceptance and use of technology into social value is determined by "governance mechanisms." [20] Trust in AI becomes the key mediator, and such trust cannot be create through messaging alone as it needs proof that people's fundamental human rights are being protected, accountability and transparency.[10]

7.2 The role of responsible innovation

Moving to a sustainable society requires abandoning the current mode of reactive technology adoption for a more proactive paradigm implemented with due diligence under responsible innovation. This involves:

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- Green AI: Focus on building energy-efficient models and measuring the carbon footprint of digital infrastructure. [8]
- Human-Centric Design: "meaningful human oversight" is required for decisions making in high-stake justice, health and credit decision domains. [2]
- Global Interoperability: Creating frameworks with safe borderless capabilities grounded in international standards like the OECD AI Principles.[22]

8.0 Recommendations

To maximize the contribution of digital innovation to long-term societal sustainability, the following recommendations are proposed for policymakers, urban planners, and technology developers.

8.1 Strengthening foundational enablers

Governments have to take into account theG7 Key Ensuring Factorsidentified for enabling digital governance:

- *Governance Frameworks Community:* National strategies that start from philosophy and move through technical coordination.[9]
- *Data Infrastructure:* Building representative and inclusive datasets for local populations[12]
- *Digital Skills:* Scholarly Investment in interdisciplinary preparation for public servants and educators to address the digital skills gap.[2]
- *AI Investment Frameworks:* Leverage sustainable impact measurement frameworks as strategic investment tools and showcase sustainability returns on investments.[30]
- *Ethical Procurement:* Public sector procurement of AI should have transparency and build mechanisms to avoid biased algorithms.[30]
- *Public Private Partnerships:* Formulating collaboration to scale successful pilots of sustainability into national solutions.[24]
- *Global cooperation:* talking among nations to share the benefits of these technological capabilities so that they are not held by a few.[9]

8.2 Implementing ethical guardrails

- *Compulsory impact assessment:* Effectively ethical impression evaluation on structured AI which are remains well known as high danger frameworks, including in wellbeing and equity.[23]
- *Transparency and Explainability:* AI actors must explain in simple terms the logic of algorithm decision-making — i.e. data sources[22]

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- *Ongoing Monitoring:* Setting up "Observatories" (finding inspiration from the UNESCO Global Observatory on AI Ethics) to monitor cases of A.I incidents, private investments into this technology and gender bias in algorithms. [37]

8.3 Fostering inclusivity and equity

- *Closing the Gender Gap:* Addressing the persistent gender bias in algorithms and promoting women's participation in STEM and AI decision-making roles.[23]
- *Accessibility by design:* Developing tools that are intuitive and usable for persons with disabilities and those with limited digital literacy.[1]
- *Support for the Global South:* Strengthening local AI ecosystems through partnerships that provide access to green compute and foundational data capabilities.[12]

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