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Ethical Framework for Artificial Intelligence and Urban Sustainability

Tatik Mariyanti[1], Indra Wijaya[2*], Sandy Setiawan [3], Chandra Lukita[4], Eamon Fletcher[5]

[1]Faculty of Economics and Business, Trisakti University, Indonesia
[2]Department of Accounting, Bank Negara Indonesia, Indonesia
[3]Department of Entrepreneurship, Bina Nusantara University, Indonesia
[4]Department of Economic and Business, University Catur Insan Cendekia, Indonesia
[5]Department of Information Technology, Eduaward Incorporation, United Kingdom
[1]tatik.mariyanti@trisakti.ac.id, [2]indrawijayabni@gmail.com, [3]sandy.setiawan@binus.ac.id,[4]chandra.lukita@cic.ac.id,
[5]eamon.fletc@eduaward.co.uk
***Corresponding Author**

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ABSTRACT

The integration of artificial intelligence (AI) into urban environments addresses sustainability challenges like resource management, transportation efficiency, and waste reduction. However, critical need for a robust ethical framework to ensure equitable and environmentally responsible implementation. The **method** proposed emphasizes a combination of community involvement, fairness, and resilience, integrating ethical principles with practical strategies to maximize societal benefits, and incorporates the use of **SmartPLS** for structural equation modeling to analyze the relationships between ethical principles, sustainability dimensions, and urban outcomes. A significant **GAP** exists in current frameworks, which often focus solely on individual-level ethics and fail to address the dynamic, systemic challenges posed by fragile social systems and the uneven global structure. The **novelty** of this approach lies in its comprehensive vision that interlinks human-centered and collectivist-oriented development, bridging socio-economic, environmental, and technological dimensions of sustainability. The **proposed** ethical framework not only mitigates risks but also fosters inclusive and resilient urban ecosystems, aligning digital innovations with the complex interconnections of the Sustainable Development Goals (SDGs) 11 (on sustainable cities).

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1. INTRODUCTION

Urban areas are undergoing a digital transformation as artificial intelligence becomes a driving force in smart city initiatives. AI optimizes energy consumption, enhances public services, and promotes sustainable development. However, its implementation raises significant ethical challenges such as decision-making bias, privacy risks, and environmental impacts. This paper introduces an updated ethical framework to ensure that AI solutions address social issues while protecting individual rights and environmental well-being[1].

Ethics has been a cornerstone of human civilization, evolving from Greek mythology and philosophy, which connected cosmic order to urban systems. In modern times, ethics shifted toward subjectivism, influenced by philosophical developments and global economic trends. Today, globalization and technological advancements have fragmented ethical principles, creating challenges in their application across diverse communities. The rise of big data offers new opportunities for societal analysis, but ethical considerations are often overlooked[2].

Global efforts to tackle sustainability challenges highlight the relevance of ethics in advancing the United Nations **Sustainable Development Goals**. SDG 11, focused on sustainable cities and communities, provides a framework for universal ethical principles. Integrating big data connects environmental, social, and infrastructural dynamics, offering innovative pathways to address complex global issues. The **method** employed in this study integrates ethical principles with the use of **SmartPLS** for structural equation modeling, providing insights into the relationships between AI implementation, sustainability outcomes, and ethical considerations. This approach allows for a comprehensive analysis of how AI systems influence urban resilience and inclusivity while identifying areas of improvement[3].

A significant **gap** exists in current ethical frameworks, which often overlook the systemic challenges posed by global inequalities and fragmented governance structures. These gaps hinder the development of robust strategies that align technological innovation with ethical imperatives, leaving vulnerable communities disproportionately affected by unintended consequences. The **novelty** of this study lies in its proposal of a holistic ethical framework that interconnects human-centered approaches with collectivist-oriented strategies. By bridging socioeconomic, environmental, and technological dimensions, this framework ensures a balanced integration of AI into urban ecosystems, addressing both individual and collective needs. The **findings** emphasize the necessity of combining ethical principles with advanced digital innovations to build resilient, equitable, and sustainable urban systems. This framework serves as a guiding tool for policymakers, technologists, and urban planners to navigate the ethical complexities of AI driven urban transformation, ensuring alignment with Sustainable Development Goals (SDGs)[4].

2. LITERATURE REVIEW

2.1. AI and Urban Sustainability

The potential of AI to transform urban systems has been well-documented in recent literature. AI enables smarter resource allocation and operational efficiencies in urban infrastructure, making cities more sustainable and livable. These technologies are particularly impactful in energy optimization and predictive maintenance, reducing waste and improving the longevity of urban assets. Furthermore, AI-powered systems help in dynamic decision-making processes, such as rerouting traffic to minimize congestion and emissions[5].

Despite these benefits, there are concerns about the uneven application of AI solutions across cities. Studies reveal that while developed nations reap the rewards of AI innovation, resource poor cities often struggle to implement these advancements. This disparity exacerbates existing inequalities, creating a digital divide in urban sustainability practices. Moreover, critics argue that an overreliance on AI systems could marginalize human decision-making and erode community agency[6].

The integration of AI into urban environments also necessitates consideration of the societal and ethical contexts in which these systems operate. Scholars emphasize the importance of contextualized solutions that address the unique needs and values of specific communities. Without such alignment, the deployment of AI may yield unintended consequences that undermine its potential benefits[7].

2.2. Ethical Challenges in AI Implementation

Ethical issues related to AI adoption in urban environments have been a focal point in academic discourse. A framework for understanding unintended consequences of machine learning, including algorithmic bias and lack of accountability. Algorithmic bias, for example, has been shown to perpetuate systemic inequities in areas such as housing allocation and law enforcement. These biases arise from training data that reflect historical inequalities, making it imperative to adopt inclusive data practices[8].

Another critical challenge lies in ensuring accountability for AI driven decisions. The opaque nature of many AI algorithms complicates efforts to establish clear lines of responsibility, particularly when decisions have significant societal impacts. Addressing this requires both technical transparency and institutional mechanisms to oversee and regulate AI applications[9].

Finally, the ethical dimensions of AI deployment extend to its ecological impact. The high energy demands of AI technologies pose a significant challenge to sustainable development. Researchers advocate for integrating ethical considerations into the design and deployment of AI systems to mitigate these adverse effects.

2.3. Data Privacy and Security

The data-intensive nature of AI systems raises significant privacy concerns. The need for robust data governance policies to safeguard personal information and ensure ethical data usage. Data breaches and unauthorized surveillance are growing risks, particularly in urban contexts where AI systems often rely on real-time data collection[10].

Techniques such as data anonymization and secure storage are frequently proposed as solutions to these challenges. However, the implementation of these techniques varies widely across jurisdictions, leading to inconsistent protection standards. Additionally, the rapid evolution of AI technology often outpaces the development of corresponding legal frameworks, leaving critical gaps in regulatory oversight.

Public trust in AI driven urban systems hinges on transparent data practices and the assurance of privacy. Studies highlight the importance of building citizen-centric policies that prioritize informed consent and empower individuals to control their data. Such approaches are vital for fostering trust and ensuring the long-term viability of AI applications in sustainable cities[11].

2.4. Ethical Framework for AI in Urban Sustainability

An ethical framework for AI in urban sustainability is essential to ensure that AI-driven solutions enhance environmental, social, and economic well-being while upholding fairness, transparency, and accountability. As cities increasingly integrate AI for smart infrastructure, traffic management, energy optimization, and waste reduction, ethical considerations must prioritize data privacy, algorithmic bias, and inclusivity to prevent social disparities. A responsible AI governance model should involve stakeholder engagement, regulatory compliance, and continuous monitoring to align technological advancements with sustainable urban development goals. By fostering trust, equity, and human-centric innovation, ethical AI frameworks can drive resilient, livable, and sustainable cities for future generations.

1. Principle 1: Equity and Justice

   AI systems must actively reduce disparities across diverse populations, ensuring fair access to benefits regardless of socioeconomic status, ethnicity, or geography. To achieve this, cities must prioritize inclusive data collection practices that accurately represent all demographic groups. Training algorithms on such diverse datasets can help mitigate biases and promote equitable outcomes[12].

   Policies should proactively address algorithmic biases to avoid perpetuating systemic inequities. For example, ongoing audits and reviews of AI systems can identify and rectify disparities in their operation. Furthermore, cities should establish oversight bodies to monitor and enforce ethical compliance, ensuring that AI implementations align with broader social equity goals.

   In practice, equity-focused AI systems should also prioritize accessibility. This involves designing interfaces and services that are user-friendly for individuals with varying levels of technological literacy and physical abilities. By embedding these considerations into the development and deployment phases, cities can create AI solutions that genuinely serve all members of society[13].

2. Principle 2: Transparency and Trust

   Cities must adopt practices that ensure AI processes are explainable and transparent. This includes clear documentation of data sources, algorithmic design choices, and their intended impact. Trust-building measures should include accessible grievance mechanisms for affected communities. Open communication about how AI systems function and how decisions are made is crucial for maintaining public confidence.

   Transparency efforts can be enhanced by implementing tools such as explainable AI (XAI), which aims to make the decision-making processes of AI systems more interpretable to humans. For example, visualizations and simplified reports can help stakeholders understand complex algorithms and their implications[14].

   In addition, fostering trust requires ongoing dialogue with communities. Public consultations and participatory governance models enable citizens to voice their concerns and influence the development of AI policies. These measures not only improve transparency but also ensure that AI systems address genuine community needs.

3. Principle 3: Privacy and Security

   Ethical AI requires stringent safeguards for personal and community data. This includes secure data storage, anonymization techniques, and strict protocols for data sharing. The implementation of robust cybersecurity measures is critical to protecting sensitive information from unauthorized access and breaches[15].

   Citizens should have control over their data through informed consent mechanisms. For instance, transparent user agreements that clearly outline how data will be used and stored can empower individuals to make informed choices. Moreover, periodic audits of data practices can ensure compliance with privacy standards and identify potential vulnerabilities.

   Privacy measures must also account for the evolving nature of AI technologies. As systems become more sophisticated, ensuring data security requires continuous updates to protective measures. Collaboration between technologists, policymakers, and legal experts is essential to staying ahead of emerging threats[16].

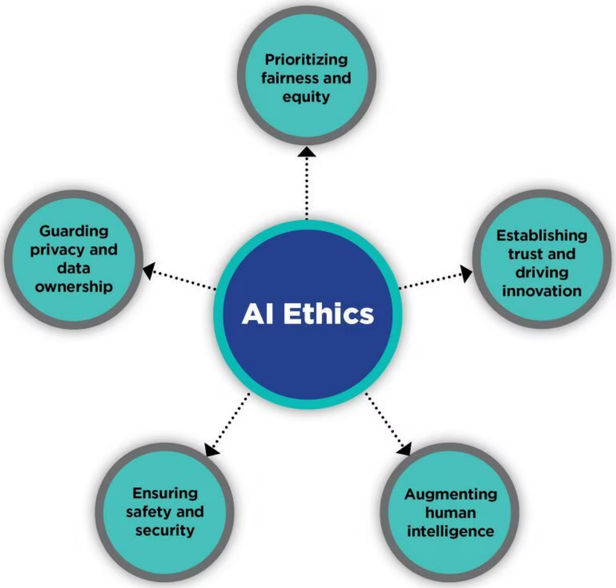

Figure 1. Ethics in AI

As shown in figure 1 illustrates the core principles of AI ethics, emphasizing key considerations for ethical implementation and governance. At the center lies ”AI Ethics,” supported by five interconnected principles: prioritizing fairness and equity, guarding privacy and data ownership, ensuring safety and security, augmenting human intelligence, and establishing trust while driving innovation. These elements collectively highlight the importance of balancing technological advancement with ethical standards to ensure AI systems align with societal values and promote responsible innovation. The diagram visually underscores the multidimensional nature of AI ethics and the need for an integrated approach to address its challenges effectively.

3. RESEARCH METHODS

Smart Partial Least Squares (SmartPLS) is a statistical tool widely used for structural equation modeling (SEM). It is particularly effective for exploring complex relationships between constructs and testing theoretical models with multiple variables. This study utilizes SmartPLS to validate the proposed ethical framework for AI and urban sustainability by examining its underlying principles and their interrelationships[17].

3.1. Model Development

Each principle is represented as a construct in the SmartPLS model, with associated indicators derived from the literature review and expert consultations. The relationships between these principles are hypothesized based on their conceptual linkages. For example, ”Transparency and Trust” is hypothesized to mediate the impact of ”Equity and Justice” on ”Public Engagement.”

3.2. Data Collection

Data for this study were collected through a survey distributed to experts in urban planning, AI ethics, and sustainability. Respondents rated their agreement with statements representing each principle using a five-point Likert scale. The sample included 150 participants from academia, government, and industry[18].

3.3. Data Analysis

The analysis involved the following steps:

1. Measurement Model Assessment

   Reliability: Internal consistency of constructs was evaluated using Cronbach's alpha and composite reliability.

   Validity: Convergent validity was assessed using Average Variance Extracted (AVE), while discriminant validity was tested through the Fornell-Larcker criterion.

2. Structural Model Evaluation

   Path coefficients and R-squared values were examined to assess the strength and significance of relationships between constructs.

3. Model Fit

   Model fit indices such as Standardized Root Mean Square Residual (SRMR) were used to evaluate the overall fit of the framework.

3.4. Measurement Model Assessment

All constructs achieved Cronbach's alpha and composite reliability values above 0.7, indicating strong internal consistency. Additionally, AVE values exceeded 0.5 for all constructs, confirming convergent validity[19].

Table 1. Reliability and Validity Metrics for Constructs

Construct	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Equity and Justice	0.85	0.90	0.65
Transparency and Trust	0.88	0.91	0.68
Privacy and Security	0.83	0.89	0.62
Environmental Responsibility	0.84	0.88	0.60
Public Engagement	0.87	0.92	0.66
Resilience and Adaptation	0.82	0.88	0.61

Table 1 illustrates the reliability and validity metrics for the constructs, demonstrating that the measurement model meets established standards for internal consistency and convergent validity.

3.5. Structural Model Evaluation

All relationships were significant at the $p < 0.05$ level, supporting the interdependencies among the framework's principles. Indicate that “Accountability and Responsibility” play a crucial role in strengthening the relationship between “Ethical Governance” and “Sustainable Decision-Making.” This suggests that organizations with robust accountability mechanisms are more likely to implement ethical policies that lead to long-term sustainability. The results reinforce the necessity of transparent frameworks to ensure that ethical considerations translate into effective and equitable public policies.

The study underscores the broader implications of these interdependencies in shaping corporate and governmental policies. By institutionalizing ethical governance principles alongside transparent accountability frameworks, organizations can create a culture of integrity that extends beyond regulatory requirements. This fosters an environment where sustainability is not merely an aspirational goal but a fundamental operational priority, ensuring that ethical decision-making remains a central tenet of long-term strategic planning.

Table 2. Path Coefficients and Significance Levels for Hypotheses

Hypothesis	**Path Coefficient**	**p-value**
Equity and Justice → Transparency	0.45	0.001
Transparency → Public Engagement	0.52	0.000
Privacy → Transparency	0.40	0.002
Environmental Resp. → Resilience	0.35	0.004
Resilience → Public Engagement	0.48	0.001

Table 2 shows the strength and significance of the hypothesized relationships. For instance, ”Transparency and Trust” significantly mediates the relationship between ”Equity and Justice” and ”Public Engagement,” highlighting the importance of clear communication in fostering community involvement[20].

4. RESULT AND DISCUSSION

The analysis of digitalization highlights the dual potential of technology as a transformative force and a source of challenges. Digitalization, as seen through the lens of artificial intelligence (AI), metaverse development, and data-driven economies, has reshaped societal functions and interactions. However, the success and ethical sustainability of digitalization hinge on its ability to address social equity, ensure responsible data use, and foster a more inclusive global ecosystem[21].

4.1. Analysis of Digitalization

Technological advancements have become one of the main drivers of socio-economic changes worldwide in recent decades. Technology enables people to connect better, gain easier access to resources and information, build entertainment and economies, create jobs, and enjoy various forms of media. However, the uneven growth of digitalization has led to a digital divide, preventing some individuals from reaping the same benefits. Furthermore, the misuse of digitalization can lead to challenges in personal development and even greater inequalities[22].

Financial and communication systems are significantly influenced by the internet, which facilitates the real-time flow of data. The realization of the power of data generated by society has fueled hopes for a data revolution. Additionally, artificial intelligence (AI) has begun to showcase its vast potential. AI, as the core of an industrial revolution, raises questions about the future of humanity. However, ethical considerations often lag behind technological progress, and only a few professionals formally study the ethics of digitalization[23].

Creating governance for technology based on truth faces significant challenges due to the fragmented nature of AI ethics. Nevertheless, global initiatives such as the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) developed by the United Nations serve as crucial tools to guide global progress. Contrary to expectations, the requirements for an Ethical Framework, introduced in the early 2010s, which positioned data and computational decisions as key components of decision-making processes, have had limited impact on the world[24].

The interconnectedness of multiple systems, real-time information, and societal responses to information, events, and crises create a complex and intertwined network. Digital platforms, applications, and technological tools have made various aspects of life more convenient, enabling the collection of massive, valuable, and widespread behavioral data. However, the relationship between local and global levels remains fragmented. This layered, hierarchical, and uneven connectivity often leads to inequality, power concentration, marginalization, and social vulnerability.

Within this context, humanity has introduced the metaverse, or the Fifth Industrial Revolution. To transform the world, significant transformative actions must begin with the implementation of moral principles to prevent the recurrence of past mistakes. Therefore, a top-down, evidence-based approach combined with a bottom-up process of individual consensus is necessary[25].

4.2. Discovery of Ethical Principles

To identify ethical principles in an urban context, it is recommended to explore existing literature on the subject, as well as documents from various institutions such as government departments, UN agencies, and digital rights frameworks. These principles can then be further refined using semantic and pragmatic analytical methods[26].

For instance, digital rights can be transformed into principles through deduction and induction. Additionally, a philosophical approach based on logical deduction remains relevant to support sustainable digital development.

For example, rights such as digital access and privacy can be redefined as ethical principles through evidence-based methodologies. Philosophical reasoning and collaboration between human and machine intelligence are essential for achieving a balance between technological development and societal progress[27].

4.3. Framework

One essential area to be able to achieve important sustainability goals is that of SDG 11 on sustainable cities and communities. Firstly, in the European Union (EU), 75% of the population lives in cities, and it is expected that, in the next three decades, around 70% of the population worldwide will be urban dwellers. Furthermore, cities are directly or indirectly responsible for over 60% of the greenhouse gas emissions in the world[28]. In fact, over 800,000 premature deaths in Europe are associated with exposure to high levels of air pollution in cities, and a significant fraction of these is connected with cardiovascular events. Due to the close connections between SDG 11 and other key SDGs (as discussed below), cities will play a significant role in the achievement of the climate targets indicated by the Paris Agreement. The range of targets within SDG 11 is quite broad, ranging from goals connected with air pollution to efficient transportation, economical aspects, and inclusion of communities[29].

As presented in the previous section, an ethical framework to achieve the SDG-11 targets requires a number of ethical principles: protective, actionable, and projection principles [25]. Protective principles are cybersecurity, anti-virality, integrity, privacy, legality, explicability, trustfulness, transparency/accessibility, accountability, and no discrimination. Actionable principles are democratization, impact based self-sustainability, literacy, digital inclusion, participation, capacity building, digital solidarity/philanthropy, collaboration, robustness, anti-discrimination, and responsibility[30]. Projection principles are multicultural city, multilevel society, internationality, autonomous society, sustainability, resilience, and sensibility/sensitivity. Having these principles come into force as a framework, it is possible to build soft regulation and social tissues to help achieve the SDG-11 targets. A summary of the framework is presented in figure 2, and a detailed discussion if provided next[31].

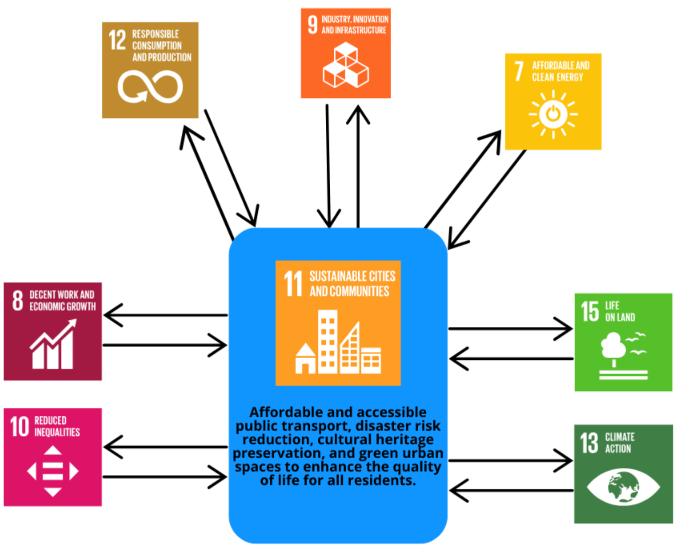

Figure 2. Ethical framework proposed in this work in the context of sustainable cities

The Sustainable Development Goals (SDGs) in fig 2 provide a comprehensive roadmap for addressing global challenges through ethical principles and innovative technologies. For example, SDG-10 (Reduced Inequalities) emphasizes the need for AI and data-driven frameworks to monitor and mitigate both spatial and social segregation, thereby promoting social integration and equality. Similarly, SDG-8 (Decent Work and Economic Growth) leverages human-machine collaboration and collective intelligence to enhance inclusivity in workspaces, such as through the metaverse and digital innovation. SDG-12 (Responsible Consumption and Production) focuses on the integration of digital tools and actionable principles to support sustainability and the circular economy[32]. On the other hand, SDG-9 (Industry, Innovation, and Infrastructure) highlights the transformative potential of distributed technologies like blockchain and AI to create more sustainable industrial operations while rethinking urban spatial designs. The transition to SDG-7 (Affordable and Clean Energy) necessitates user-centered and data-driven energy systems, tailored to support Industry 5.0 and a computationally intensive future. Furthermore, SDG-15 (Life on Land) requires AI-driven systems to monitor and manage land use efficiently, encouraging green cities and global collaborations. Lastly, SDG-13 (Climate Action) calls for carbon-neutral cities and resilience-building through early warning systems and AI-driven policymaking to combat climate crises. Together, these SDGs demonstrate the critical role of AI and digital frameworks in fostering sustainability, equality, and resilience, while emphasizing the ethical principles necessary to achieve these goals responsibly[33].

5. MANAGERIAL IMPLICATION

The findings of this study provide valuable insights for managers and policymakers in designing and implementing ethical AI frameworks within urban environments, ensuring that digital innovations align with sustainability goals and societal equity.

5.1. Strategic AI Governance for Urban Sustainability

Effective AI governance in urban sustainability requires a structured and transparent decision-making process. City administrators and technology leaders must ensure that AI-driven systems align with ethical considerations and long-term sustainability goals. By implementing governance frameworks, policymakers can mitigate the risks of algorithmic bias, privacy concerns, and security vulnerabilities while optimizing urban management.

Furthermore, AI governance should involve a multi-stakeholder approach, integrating input from government institutions, private enterprises, and civil society. Regular audits, impact assessments, and ethical reviews should be conducted to ensure that AI systems remain accountable and fair. This collaborative approach enables cities to leverage AI for enhancing urban resilience while maintaining trust and equity among citizens.

5.2. Ethical AI Deployment in Smart Cities

Deploying AI in smart cities requires a balance between innovation and ethical responsibility. City planners must ensure that AI applications in areas such as transportation, energy management, and public services prioritize inclusivity and fairness. Ethical guidelines should be established to safeguard against discrimination and digital exclusion, ensuring that AI benefits all communities, including marginalized groups.

Additionally, cities must implement transparent AI models that allow for explainability and public engagement. Providing accessible explanations of AI-driven decisions builds trust and encourages citizen participation. Open data policies and collaborative research initiatives with academic institutions can further enhance the ethical implementation of AI, promoting both technological advancement and societal well-being.

5.3. Data Privacy and Security in AI Implementation

As AI systems rely on vast amounts of data, protecting personal and community privacy is paramount. City governments should enforce stringent data protection policies, ensuring that AI applications comply with privacy regulations such as GDPR and other local laws. The implementation of secure data encryption and anonymization techniques can help prevent data misuse and unauthorized access.

Educating citizens about their digital rights and data protection measures fosters a culture of awareness and accountability. Municipalities should establish dedicated AI ethics committees to oversee data security practices and respond to public concerns. By embedding privacy-centric principles into AI systems, urban environments can enhance their technological infrastructure without compromising citizen trust.

5.4. Integrating AI for Sustainable Urban Development

AI plays a crucial role in achieving sustainable urban development by optimizing resource management and reducing environmental impact. City administrators should leverage AI-powered predictive analytics to enhance energy efficiency, water conservation, and waste management systems. Smart city initiatives that integrate AI-driven insights can contribute to the realization of Sustainable Development Goals (SDGs), particularly SDG 11 on sustainable cities.

The integration of AI must be accompanied by strategic policies that promote responsible consumption and production. Urban leaders should collaborate with technology providers and environmental organizations to develop AI solutions that support circular economy practices. By aligning AI adoption with sustainability objectives, cities can drive long-term ecological and economic benefits.

6. CONCLUSION

The rapid evolution of machine capabilities demands a shift in motivation beyond simply creating smarter methods to perform human-like tasks. Historically grounded in physicalism, machines are still far from replicating human reasoning and interpretability. Despite excelling in tasks such as text generation, analysis, and even creative endeavors like painting, machines lack intrinsic human qualities like open interpretability and freedom. Without proper regulation, this industrialization risks dehumanizing society and exacerbating the digital divide, further alienating underserved communities from technological benefits. To prevent these negative outcomes, ethical frameworks must ensure that machines complement humanity rather than undermine its fundamental values.

At the same time, machines offer unique opportunities to address systemic vulnerabilities and inequalities within social systems. Computational frameworks provide transparency and accountability, enabling governance models that minimize human biases and improve decision-making. By fostering collective intelligence systems, machines can enhance human capacities for abstract thinking and high-level decision-making while taking on repetitive tasks. This human-machine collaboration holds the potential to integrate diverse perspectives into governance processes, scale decision-making, and bridge the gaps in participation. However, ethical considerations must be embedded into these systems from their inception to create a balanced and mutually beneficial relationship between humans and machines.

To achieve these goals, a new universal ethical framework is required one that draws upon evidence provided by science and emphasizes actionable and projection principles alongside traditional protective guidelines. This framework should aim to address the interconnections among various SDGs, with particular attention to SDG-11 and its focus on sustainable cities. Such advancements could inform more effective urban planning strategies while addressing broader global challenges like greenhouse emissions and public health. Moreover, proposals for a new SDG-18 dedicated to AI and digital technologies emphasize the need for specific regulations and audits, ensuring that technological innovation aligns with ethical standards and contributes to a more equitable and sustainable future for humanity.

7. DECLARATIONS

7.1. About Authors

Tatik Mariyanti (TM) iD https://orcid.org/0000-0002-0560-4888

Indra Wijaya (IW) iD https://orcid.org/0009-0002-4772-8085

Chandra Lukita (CL) iD https://orcid.org/0009-0006-6035-8241

Sandy Setiawan (SS) iD https://orcid.org/0009-0001-2203-6579

Eamon Fletcher(EF) iD https://orcid.org/0009-0000-5048-2165

7.2. Author Contributions

Conceptualization: TM, IW, and EF; Methodology: TM; Software: CL; Validation: TM and IW; Formal Analysis: TM and TW; Investigation: CL; Resources: SS; Data Curation: SS; Writing Original Draft Preparation: TM and TW; Writing Review and Editing: EF; Visualization: TM; All authors, TM, IW, CL, SS and EF, have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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