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Article

The co-evolution of AI technology and information environment: Diagnosing social impacts and exploring governance strategies

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Abstract: The rapid advancement of artificial intelligence (AI) technology is profoundly transforming the information ecosystem, reshaping the ways in which information is produced, distributed, and consumed. This study explores the impact of AI on the information environment, examining the challenges and opportunities for sustainable development in the age of AI. The research is motivated by the need to address the growing concerns about the reliability and sustainability of the information ecosystem in the face of AI-driven changes. Through a comprehensive analysis of the current AI landscape, including a review of existing literature and case studies, the study diagnoses the social implications of AI-driven changes in information ecosystems. The findings reveal a complex interplay between technological innovation and social responsibility, highlighting the need for collaborative governance strategies to navigate the tensions between the benefits and risks of AI. The study contributes to the growing discourse on AI governance by proposing a multi-stakeholder framework that emphasizes the importance of inclusive participation, transparency, and accountability in shaping the future of information. The research offers actionable insights for policymakers, industry leaders, and civil society organizations seeking to foster a trustworthy and inclusive information environment in the era of AI, while harnessing the potential of AI-driven innovations for sustainable development.

Keywords: artificial intelligence; information ecosystem; social impact; governance strategies; sustainability

1. Introduction

The rapid advancement of artificial intelligence (AI) technology is profoundly transforming the information ecosystem, reshaping the ways in which information is produced, distributed, and consumed. From personalized content recommendations to automated news generation, AI is becoming increasingly integrated into the fabric of our digital lives. As AI continues to evolve and permeate various domains, it is crucial to examine its impact on the information environment and explore strategies for ensuring the reliability and sustainability of information in the age of AI.

Existing research has highlighted both the promises and perils of AI in the context of information. On one hand, AI-driven innovations have the potential to enhance information accessibility, facilitate knowledge discovery, and promote personalized learning. On the other hand, concerns have been raised about the risks of AI-generated misinformation, algorithmic bias, and the erosion of privacy. As AI becomes more sophisticated and ubiquitous, it is imperative to address the unresolved tensions between the benefits and drawbacks of AI in shaping the information landscape.

Despite the growing body of literature on AI and information, there remains a

need for a comprehensive examination of the multifaceted impact of AI on the information ecosystem. Previous studies have often focused on specific aspects, such as algorithmic recommendation systems or AI-generated content, without providing an integrated analysis of the interplay between technological advancements and societal implications. Moreover, the rapid pace of AI development necessitates an updated understanding of the current challenges and future directions for ensuring a trustworthy and inclusive information environment.

To bridge these gaps, this study aims to conduct a holistic investigation of the impact of AI on the information ecosystem and propose policy measures for promoting the harmonious co-evolution of AI technology and social values. Specifically, the research objectives are threefold: 1) to diagnose the changes brought about by AI in the production, distribution, and consumption of information; 2) to examine the challenges and opportunities for building a sustainable and reliable information environment in the age of AI; and 3) to propose policy recommendations and governance strategies for harnessing the benefits of AI while mitigating its risks.

The study employs a mixed-methods approach, combining a comprehensive literature review, expert interviews, and case studies to provide a nuanced understanding of the research problem. The findings contribute to the growing discourse on AI governance by offering a multi-stakeholder perspective and actionable insights for policymakers, industry leaders, and civil society organizations.

The remainder of this paper is structured as follows. Section 2 presents the theoretical background, reviewing key concepts and frameworks related to AI and the information ecosystem. Section 3 describes the research methodology, including data collection and analysis procedures. Section 4 presents the findings, highlighting the major themes and insights that emerged from the study. Section 5 discusses the implications of the findings, situating them within the broader context of AI governance and information policy. Finally, Section 6 concludes the paper by summarizing the key contributions, limitations, and future research directions.

2. Theoretical background

This section reviews the key concepts and theories related to AI technology and the information ecosystem, providing a foundation for the study's analytical framework.

2.1. AI technology: Definitions and typologies

Artificial intelligence (AI) refers to the development of computer systems that can perform tasks typically requiring human intelligence, such as visual perception, speech recognition, decision-making, and language translation (Russell and Norvig, 2021). AI technologies can be broadly categorized into two types: narrow AI, which is designed to perform specific tasks, and general AI, which exhibits intelligent behavior across a wide range of domains. The current state of AI primarily consists of narrow AI applications, such as machine learning algorithms for pattern recognition and prediction (Jordan and Mitchell, 2015).

2.2. The information ecosystem in the age of AI

The information ecosystem encompasses the complex network of actors, technologies, and practices involved in the creation, dissemination, and consumption of information (Nardi and O'Day, 1999). With the advent of AI, the information ecosystem is undergoing significant transformations, as AI technologies are increasingly integrated into various stages of the information lifecycle (Haider and Sundin, 2019). AI-driven personalization, automated content generation, and algorithmic curation are reshaping the ways in which information is produced, distributed, and accessed.

2.3. Theoretical perspectives on AI and information

Previous research has employed various theoretical lenses to examine the relationship between AI and information. The theory of algorithmic accountability emphasizes the need for transparency and responsibility in the design and deployment of AI systems that shape information flows (Diakopoulos, 2016). The concept of algorithmic governance highlights the growing power of AI in regulating and controlling information spaces (Just and Latzer, 2017). Additionally, theories of information justice and data ethics underscore the importance of fairness, inclusivity, and human rights in the development and use of AI technologies (Floridi, 2019; Taylor, 2017).

However, existing theoretical frameworks often fall short in capturing the full complexity and dynamism of the AI-information nexus. The rapid pace of technological change and the emergence of novel AI applications require a continuous refinement and extension of conceptual tools to adequately address the evolving challenges and opportunities (Gunkel, 2022). Moreover, there is a need for a more holistic and integrated approach that considers the interplay between technological, social, and policy dimensions in shaping the information ecosystem (Crawford and Paglen, 2019).

Building upon these theoretical foundations, this study proposes an analytical framework that integrates insights from AI ethics, information studies, and policy sciences to provide a comprehensive understanding of the impact of AI on the information ecosystem. The framework considers three key dimensions: (1) the technical affordances and limitations of AI systems; (2) the social and ethical implications of AI-driven information practices; and (3) the policy and governance challenges associated with ensuring the reliability, fairness, and sustainability of the information environment in the age of AI. By bridging disciplinary boundaries and offering a multi-level analysis, this framework seeks to contribute to the advancement of theoretical knowledge and inform the development of effective policy interventions.

3. Scope and methodology of the research

This study seeks to address the following research questions:

1) At what stage of development is AI technology currently, and what are its future prospects? In particular, what are the evolutionary aspects and ripple effects of component technologies and platform technologies, respectively?
2) What technical and social limitations and problems are being revealed in the

process of AI technology advancement? Specifically, what risk factors and issues are emerging from the perspective of the information environment?

3) What changes is AI technology bringing about in the overall production, distribution, and use of information? What impact does this have on the sustainability of the information environment?
4) What are the policy vision and goals for effectively responding to the development of AI technology and changes in the information ecosystem? What are the practical tasks in each dimension of technology, policy, and society?
5) What are the measures to realize a trustworthy information society through communication and cooperation among various stakeholders? What are the roles and directions of solidarity for each actor?

To address these research questions, this study employs a comprehensive approach encompassing AI technology trends, social impacts, and policy challenges. The specific scope and methodology of the research are as follows.

This study aims to diagnose the impact of AI technology development on the information ecosystem and explore countermeasures. To achieve this, I attempt a comprehensive approach encompassing AI technology trends, social impacts, and policy challenges. The specific scope and methodology of the research are as follows.

Firstly, I clarify the concept and types of AI technology and provide an overview of the current status and prospects of major technological advancements. I examine the characteristics and trends of AI component technologies such as natural language processing and computer vision, as well as platform technologies like agents and metaverse. Through literature review, I survey the latest research achievements and development directions in the relevant fields. Particular attention is given to the socio-economic ripple effects and future prospects arising from technological evolution.

Secondly, I diagnose the limitations and challenges inherent in AI technology. I review technical and social issues at the component technology level, such as bias, explainability, and privacy, as well as limitations at the platform level, including the absence of metacognition and the erosion of trustworthiness. From a technical perspective, I conduct literature analysis on the operating principles and performance evaluation metrics of the relevant technologies. From a social perspective, I perform empirical analysis on cases of social problems caused by technology application. Through this, I derive the tasks that need to be addressed along with technological advancement.

Thirdly, I analyze the impact of AI technology development on the information environment. I focus on the spread of AI-generated data, changes in user behavior due to the transformation of information services, and sustainability issues in the information ecosystem. By analyzing statistical data and empirical cases, I identify the changing trends and characteristics of the information environment. Based on this, I diagnose the opportunity and risk factors brought about by AI technology in the information ecosystem.

Fourthly, I propose policy directions in response to the changes in the information ecosystem. I concentrate on exploring measures to enhance the social responsibility of AI technology, manage and qualitatively control AI-generated data, and establish cooperative governance among stakeholders. Based on the previously identified issues and challenges, I suggest response tasks in each dimension of technology, policy, and

society. **Figure 1** illustrates the research scope and methods employed in this study.

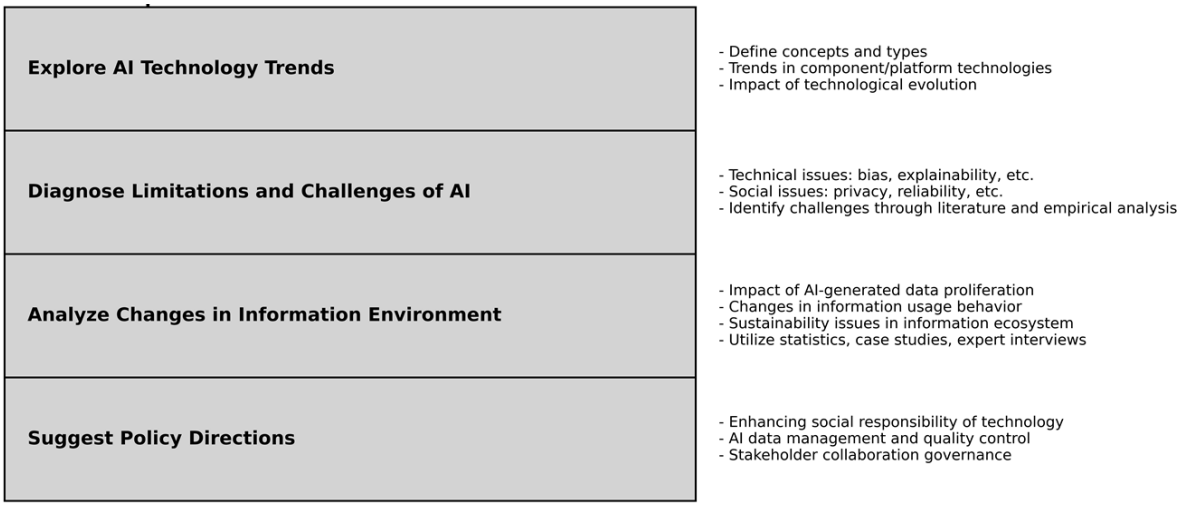

Figure 1. Research scope and methods.

Through this research scope and methodology, the study aims to address the following research questions:

1) At what stage of development is AI technology currently, and what are its future prospects? In particular, what are the evolutionary aspects and ripple effects of component technologies and platform technologies, respectively?
2) What technical and social limitations and problems are being revealed in the process of AI technology advancement? Specifically, what risk factors and issues are emerging from the perspective of the information environment?
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5) What are the measures to realize a trustworthy information society through communication and cooperation among various stakeholders? What are the roles and directions of solidarity for each actor?

Through this research scope and methodology, the study aims to address the following research questions, as visualized in **Figure 2**.

In the process of answering these questions, this study aims to provide a comprehensive overview of the social discourse and policy agenda surrounding AI technology and offer a starting point for exploring a desirable future vision. At a time when the innovativeness and disruptiveness of AI technology are complexly interacting in the changing landscape of the information environment, a socio-scientific reflection that seeks the harmonious co-evolution of technology and society is required. In this regard, finding a balance between the inclination towards technological innovation and the excessive vigilance against technological risks, and practicing collective intelligence towards a healthy information society that guarantees the values of trust and inclusion emerges as an important task.

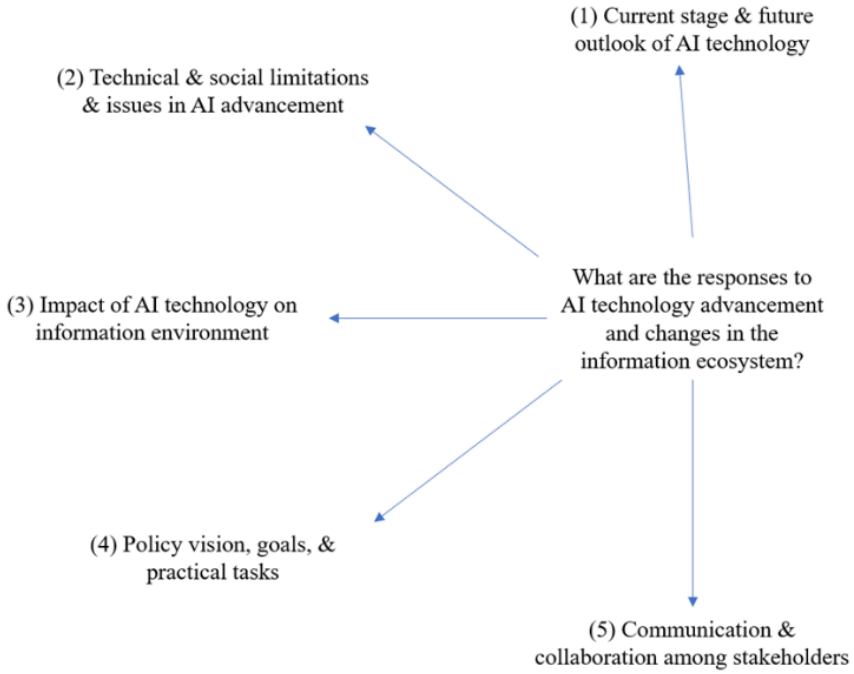

Figure 2. Research questions in a mind map.

Under this recognition, this study seeks to contribute to the relevant academic community and policy discourse while also helping to enhance public understanding and activate social discussion. In an era where the social influence of AI technology is expanding in all directions, questioning the intersection between technology and society and broadening the horizon of communication and solidarity will itself be a meaningful intellectual practice.

4. AI technology trends and prospects

4.1. Concept and classification of AI technology

In this study, I categorized artificial intelligence (AI) technology into two categories: component technology and platform technology (Russell and Norvig, 2016). Component technology is defined as the technology that performs individual functions constituting an artificial intelligence system, while platform technology is defined as the technology that provides the infrastructure for integrating and utilizing these component technologies. **Table 1** presents a classification of AI technologies, illustrating examples of both element technologies and platform technologies.

Table 1. Classification of AI technologies.

Element Technologies	Platform Technologies
Knowledge Representation	Language Models
Inference	Speech Recognition
Machine Learning	Computer Vision
Natural Language Processing	Autonomous Driving
Computer Vision	Smart Factory

4.1.1. AI as component technology

Component technology includes detailed technologies necessary for implementing artificial intelligence, such as knowledge representation, inference, machine learning, natural language processing, and computer vision, as components of an artificial intelligence system (Goldberg, 2017).

Knowledge representation and inference are key component technologies for implementing expert systems, which express expert knowledge in a form that computers can process and derive conclusions from (Jackson, 1986). Machine learning technology improves information processing performance by having computers learn patterns from data and generate models (Bishop, 2006), while natural language processing is a component technology for computers to understand and process human language (Martin, 2009). Computer vision is a technology that recognizes and interprets images and videos (Szeliski, 2022). These component technologies contribute to enhancing the performance of artificial intelligence systems by providing specialized functions for individual artificial intelligence applications.

4.1.2. AI as platform technology

Platform technology is a foundational technology that increases the usability of artificial intelligence technology by organically linking component technologies and providing an integrated environment (Haenlein and Kaplan, 2019). Representative AI platforms include IBM Watson, ChatGPT, Gemini, and others (Ramesh et al., 2022; Weizenbaum, 1976).

AI platforms provide artificial intelligence technology through large-scale data processing, machine learning algorithm libraries, API provision, and more (Sharda et al., 2021). They also offer large-scale computing resources on a cloud basis, allowing businesses and developers to utilize artificial intelligence technology more easily.

Recently, there has been a trend of AI platforms providing general-purpose artificial intelligence APIs such as language models, speech recognition, and visual intelligence (Bommasani et al., 2021). In addition, AI platforms specialized for specific domains such as autonomous driving and smart factories are also emerging (Kusiak, 2018).

4.2. Current status and prospects of major AI technologies

4.2.1. Trends in key component technologies such as language models and computer vision

In the field of natural language processing, large-scale language models based on the transformer architecture are gaining attention. Language models such as GPT-3 (Brown et al., 2020) and BERT (Devlin et al., 2019) demonstrate language understanding and generation capabilities approaching human-level by learning hundreds of billions of parameters. In particular, through few-shot learning, they have become capable of performing new tasks with only a small amount of data. Language models are expected to evolve into more powerful foundational models encompassing knowledge, reasoning, and common sense (Bommasani et al., 2021).

In the field of computer vision, deep neural network models based on CNN are showing outstanding performance in image recognition, object detection, semantic segmentation, and more. Recently, research actively adopting transformer models

from the NLP domain, such as Vision Transformer (Dosovitskiy et al., 2020), is underway. Additionally, text-based image generation models like DALL-E and Stable Diffusion are newly gaining attention (Ramesh et al., 2021). The development of integrated perception models utilizing large-scale multimodal data is also emerging as an important research topic.

4.2.2. Trends in platform technologies such as AI agents and metaverse

AI agents are utilized in chatbots, virtual assistants, customer service systems, and more, performing natural language interaction, task execution, and personalized service provision. Recently, conversational AI like ChatGPT, equipped with powerful language models such as GPT-3, has emerged, opening new horizons for agent technology. Along with this, multimodal agents, enhancing autonomy and adaptability, and resolving ethical issues are being raised as important research challenges.

Metaverse is a platform for social interaction through avatars in a three-dimensional virtual world, with expanding utilization in various fields such as gaming, education, and collaboration. AI technology is becoming a key driver for enhancing the metaverse experience by being applied to avatar generation and control, interaction with NPCs, personalized content recommendation, and more. In the future, the metaverse is expected to evolve into an even more creative and open ecosystem by combining with technologies such as Web3, NFT, and blockchain.

Table 2. Trends in the development of AI component technologies and platform technologies.

Category	Technical domain	Key trends	Core model/platform	Development direction
Component Technologies	Natural Language Processing	• Large-scale language models based on Transformers • Human-level language understanding and generation capabilities • Few-shot learning capabilities	GPT-3, BERT	Developing powerful foundation models
	Computer Vision	• High-performance CNN-based deep neural network models • Active research on NLP-inspired techniques such as Vision Transformer	Vision Transformer, DALL-E, Stable Diffusion	Developing large-scale multi-modal data integration models
	Speech Recognition	• End-to-end models such as RNN-Transducer and Transformer • Enhanced practicality through streaming speech recognition and semi-supervised learning	Conformer	Integrating with speech synthesis technology
Platform Technologies	AI Agent	• Applied to chatbots, virtual assistants, and more • Providing natural language interaction, task execution, and personalized services	ChatGPT	Developing multi-modal agents with enhanced autonomy and adaptability
	Metaverse	• Social interaction in 3D virtual worlds • Expanding applications in gaming, education, collaboration, and more	Zepeto, Roblox, Fortnite	Evolving into a creative and open ecosystem combined with Web3, NFT, and blockchain technology
	Others	• Convergence with autonomous driving, robotics, smart healthcare, and more • Developing specialized AI models, data management systems, and edge computing	Tesla Autopilot, IBM Watson Health	Creating practical value through specialized platform development

In addition, artificial intelligence platform technology is being integrated into various fields such as autonomous driving, robotics, and smart healthcare, leading

innovation. The complex development of domain-specific artificial intelligence models, data collection and management systems, edge computing environments, and more is creating practical value. **Table 2** summarizes the trends in the development of AI component technologies and platform technologies.

5. Limitations and challenges of AI technology development

Although artificial intelligence technology is making remarkable progress, it also inherently possesses technical and social limitations and challenges. This chapter aims to examine the current problems and challenges faced by component technologies and platform technologies, respectively. **Table 3** provides an overview of category-specific technical limitations in AI technology.

Table 3. Category-specific technical limitations.

Categorization of Technological Limitations	Specific Challenges and Concerns-
Limitations of Component Technologies	Hallucination
	Bias
	Adversarial Attack
	Privacy Violation
	Model Vulnerability
Limitations of Platform Technologies	Lack of Meta-cognition
	Ensuring Fairness and Accountability
	Social Issues within Metaverse Platforms
	Privacy Protection and Ethical Issues

5.1. Limitations of component technologies—Hallucination, bias, etc.

AI component technologies are becoming more advanced and sophisticated, but they still reveal limitations. First, 'hallucination' is a frequent problem in natural language processing or question-answering systems. This refers to the model generating plausible content as if it were factual, but in reality, it is incorrect information that differs from facts or lacks evidence (Dziri et al., 2021). This problem, which often occurs in large-scale language models such as GPT-3, raises doubts about the explainability and reliability of the models.

Moreover, biases inherent in the training data are reflected in the models, sometimes leading to discriminatory and inappropriate results. For example, there have been reported cases of facial recognition systems showing high misrecognition rates for certain races or genders (Buolamwini and Gebru, 2018), or natural language processing models generating gender-discriminatory expressions (Bolukbasi et al., 2016). This is emerging as an important issue in terms of fairness and ethics of technology.

In addition, problems such as adversarial attacks, privacy infringement, and model vulnerability are also pointed out as limitations of component technologies (Akhtar and Mian, 2018). It can be said that overcoming these limitations through systematic and continuous research and developing more robust and reliable AI component technologies is an important task.

5.2. Limitations of platform technologies—Lack of metacognition, trustworthiness, etc.

Artificial intelligence platform technology also faces several limitations. First, many current AI agents lack the ability to recognize their own capabilities and limitations, that is, 'metacognition'. Even if they effectively perform a given task, they may provide inappropriate or unfounded answers to questions beyond their knowledge scope. This highlights the need for agents to have 'self-awareness' to recognize their own limitations and properly convey them to users.

Additionally, privacy protection and ensuring ethics are raised as important challenges in conversational agents and recommendation systems. It is urgent to increase transparency and explainability regarding the collection and utilization of user data, and to establish governance and regulatory frameworks to prevent malicious use (Bostrom and Yudkowsky, 2018). Moreover, technical and institutional measures should be put in place to ensure fairness and accountability in decision-making processes.

Metaverse platforms that utilize avatars and AI agents provide opportunities for new social interactions and value creation, but they are also exposed to problems such as addiction, cyberbullying, and copyright infringement. Along with technical safeguards, social response measures such as improving user awareness and revising laws and regulations are required.

6. Impact of AI technology development on the information ecosystem

6.1. Proliferation of generated data and changes in information quality

The development of artificial intelligence technology is bringing about fundamental changes in data generation methods and the information environment. In particular, the recent rapid spread of AI-generated data deserves attention as it entails the possibility of causing qualitative changes in information as well as various social problems (Pariser, 2011; Vosoughi et al., 2018). **Table 4** summarizes the key trends and implications of AI's impact on the information ecosystem.

Table 4. Category-specific technical limitations.

Category	Trends	Implications
Data Expansion	Increase in multi-modal content generation	Information overload, decreased trust in information
Information Environment	Changes in information environment	Misinformation, bias, and conflict
Applications	Increased use in journalism, art, entertainment, and other fields	Job displacement, creative industry concerns
Concerns	AI bias, algorithmic bias, black box problems	Social unrest, lack of quality control and management systems

6.1.1. Characteristics and proliferation trends of AI-generated data

AI-generated data refers to content in various forms such as text, images, voice, and video created through artificial intelligence algorithms. Generative models such as GPT-3, DALL-E, and Stable Diffusion produce highly realistic and creative outputs based on vast training data and given prompts (Ramesh et al., 2021). Such AI-

generated data holds great potential in that it can mass-produce content while minimizing human intellectual effort.

The proliferation of AI-generated data is evident in various domains. In journalism, AI-powered tools are being used for article writing, fact-checking, and personalized news recommendations (Carlson, 2015). The art and entertainment industries are also witnessing the rise of AI-generated content, such as music compositions, paintings, and game assets (Yannakakis, 2020). The efficiency and diversity of content production are greatly enhanced through the automation and personalization of data generation.

However, the rapid increase in AI-generated data also raises concerns about information quality and reliability. The potential for AI models to generate biased, misleading, or factually incorrect content is a significant issue (Guzman and Lewis, 2020). Moreover, the mass production of AI-generated data may lead to the homogenization of content and the erosion of human creativity (Elgammal, 2020). These concerns highlight the need for robust quality control mechanisms and ethical guidelines for AI-generated content.

6.1.2. Impact on information ecosystem and social implications

The proliferation of AI-generated data has far-reaching implications for the information ecosystem and society at large. One major concern is the potential for AI-generated content to spread misinformation and disinformation (Vosoughi et al., 2018). As AI models become more sophisticated in generating realistic text and images, it becomes increasingly difficult to distinguish between authentic and synthetic content. This can lead to the amplification of fake news, propaganda, and conspiracy theories, undermining the trustworthiness of the information environment.

Another significant impact is the potential for AI-generated content to reinforce existing biases and discrimination (Noble, 2018). If the training data used to develop AI models contains biases, the generated content may perpetuate and even amplify these biases. This can lead to the underrepresentation or misrepresentation of certain groups, exacerbating social inequalities.

Moreover, the increasing reliance on AI-generated content may have implications for human creativity and job displacement. As AI models become more proficient in generating high-quality content, there is a risk of human creators being replaced or devalued. This raises questions about the future of creative industries and the need for policies that support human-AI collaboration.

To address these challenges, it is crucial to develop robust governance frameworks and ethical guidelines for AI-generated content. This includes establishing standards for data quality, transparency, and accountability in AI content generation processes. Moreover, public awareness and media literacy initiatives are necessary to help individuals critically evaluate and navigate the increasingly complex information landscape shaped by AI technologies.

6.2. Changes in information distribution and usage behavior

AI technology greatly affects not only data generation methods but also the distribution of information and the behavior of users. The advancement of search and curation services, personalized information provision, and the emergence of new

interaction methods are increasing the dynamics of the information ecosystem while triggering various changes.

6.2.1. Changes in search and curation services

Traditional search services were limited to simple information retrieval based on keyword matching, but the introduction of AI technology has enabled more sophisticated and contextual searches. Major search engines like Google and Bing utilize natural language processing models such as BERT and RankBrain to understand the meaning of search queries and provide results that match the user's intent (Nayak, 2019). Furthermore, multimodal search functions such as image search through Vision AI and voice recognition-based search are also being strengthened.

Moreover, search services incorporating conversational AI such as ChatGPT and Bard are recently gaining attention. Rather than simply listing related web pages, they generate direct answers to queries, thereby enhancing the convenience of search and the efficiency of information acquisition. Microsoft's New Bing and Google's AI Search are representative examples, and more innovative cases are expected to emerge in the future.

AI technology has also established itself as a key driver in the recommendation and curation field. YouTube, Netflix, Amazon, and others provide personalized content through recommendation algorithms that learn from large-scale user behavior data. Various techniques such as collaborative filtering, matrix factorization, and deep learning are applied to improve the accuracy and diversity of recommendations (Falk, 2019). This leads to increased user satisfaction as well as strengthened competitiveness of platforms. **Table 5** compares traditional methods with AI-applied technologies in search and curation services.

Table 5. Changes in search and curation services.

Service type	Traditional method	AI technology applied
Search	Keyword Matching Based Search	Semantic Understanding and Contextual Search (BERT, Rank Brain, etc.)
		Multimodal Search (Image, Voice, etc.)
		Conversational AI Search (ChatGPT, Bard, etc.)
Recommendations and curation	Simple Popularity Based	Personalized Recommendations (Collaborative Filtering, Matrix Factorization, Deep Learning, etc.)

6.2.2. Changes in users' information access and usage behavior

The utilization of AI in information services is also bringing changes to users' information access and usage behavior. First, as personalized information provision becomes commonplace, users consume content tailored to their interests. However, this can cause problems such as information imbalance, filter bubbles, and echo chambers, requiring balanced information acquisition (Pariser, 2011a; Pariser, 2011b).

Direct interaction with new AI technologies is also expanding. Communication with conversational agents such as chatbots and virtual assistants, and the use of immersive information based on VR/AR, are changing the existing unidirectional information consumption behavior. While the interest and engagement in information acquisition are increasing, side effects such as excessive dependence on algorithms and distortion of reality perception are also concerning.

On the other hand, there is also a trend of an increasing number of users participating in the production and distribution of information due to AI technology. Anyone can easily utilize AI tools to create and share text, images, videos, and more. This contributes to the expression of public creativity and the expansion of information diversity, but at the same time, concerns such as copyright infringement and the indiscriminate spread of AI-generated content are also raised (Elgammal, 2020).

As such, the changes in information distribution and usage behavior caused by AI show coexisting positive functions such as promoting the democratization and personalization of information, along with dysfunctions such as information bias and social division. Multifaceted efforts such as digital literacy education corresponding to technological advancements, legal system improvements, and the formation of social consensus are required. **Table 6** outlines the advantages and disadvantages of these changes in information utilization.

Table 6. Advantages and disadvantages of changes in information utilization.

Change Factor	Advantages	Disadvantages
Personalized Information Delivery	Consumption of Interest-Specific Content	Information Overload, Filter Bubbles, Echo Chambers
New Interaction Methods (Conversational AI, VR/AR, etc.)	Increased Engagement and Immersion in Information	Overreliance on Algorithms, Distorted Reality Perception
Expansion of Public Creation and Information Sharing	Enhanced Creativity, Increased Information Diversity	Copyright Infringement, Unrestrained Spread of Information

6.3. Concerns and challenges for the sustainability of the information ecosystem

AI technology is bringing innovation to information generation, distribution, and usage as a whole, but at the same time, it is also acting as a factor threatening the sustainability of the information ecosystem. Data bias and quality deterioration, fairness impairment due to algorithm monopoly, and the deepening of information gaps and digital inequality are pointed out as elements hindering the creation of a sound information ecosystem.

First, the issue of bias in AI training data can undermine the diversity and equity of the information ecosystem. Web data often fails to achieve demographic and cultural balance, and AI models trained on this data run the risk of producing and distributing information biased towards specific groups or values (Noble, 2018). The problems of data gaps and algorithmic discrimination in dimensions such as gender, race, and ideology can hinder social integration and damage the democratic information environment.

The lack of qualitative control over AI-generated data also threatens the credibility of the information ecosystem. If information of unclear authenticity or manipulated information is distributed in large quantities, it can exacerbate user confusion and hinder the formation of healthy public opinion. The spread of false information, privacy infringement, and copyright issues are factors that can undermine trust in AI information services as a whole.

Furthermore, the monopoly of AI algorithms by big tech companies raises concerns in terms of information accessibility and diversity. As a small number of

companies dominate vast amounts of data and algorithms, they come to control the process of information distribution such as search and recommendation, which can impair the pluralism and publicness of information (Zuboff, 2019). Restrictions on users' choices and information bias based on commercial interests act as obstacles to free public opinion formation and a democratic discussion culture.

The deepening of AI informatization can also cause problems of information gaps and digital inequality. The beneficiaries of new services tend to be concentrated among the wealthy and younger generations with relatively high technological accessibility, which deepens information imbalances between classes and generations (van Dijk, 2020). Moreover, differences in digital literacy directly lead to gaps in AI social adaptation capabilities, potentially becoming a factor in social polarization.

7. Policy directions in response to changes in the information ecosystem

The rapid development of AI technology is bringing about extensive and profound changes throughout our society. Economic opportunities such as industrial productivity innovation and the creation of new businesses are being raised in a complex manner along with social risk factors such as labor substitution and algorithmic discrimination. In particular, AI platforms, which have established themselves as key channels for information distribution, are causing dysfunctions such as data bias, filter bubbles, and privacy infringement while providing benefits like improved information accessibility and personalized services.

As the social impacts and issues surrounding AI technology diversify, it is urgently required to explore policies to maximize the positive values of technological development and minimize negative externalities. Especially for building a sound and sustainable information ecosystem, it is necessary to closely examine policy tasks and implementation directions in major areas such as AI technology regulation, data management, and stakeholder cooperation.

7.1. Enhancing social responsibility in AI technology development and utilization

Above all, strengthening social responsibility throughout AI technology development and utilization is emerging as the core of the policy agenda. In order to increase the social acceptability of technology and secure trust, an approach is needed to proactively consider ethical issues and embody the values of responsibility and inclusiveness from the R&D stage.

To this end, first, it is required to establish social ethics principles and a normative system to be applied to AI technology through a deliberation process involving various stakeholders. It should serve as a direction for development and utilization by balancing the benefits and risks of technology and establishing common value standards for society. In addition, institutional mechanisms such as self-regulation, incentives, and constant monitoring should be sought together to ensure the effectiveness of ethical principles.

Furthermore, the realization of responsibility needs to be supported by innovation at the technical level as well. In particular, efforts to enhance the transparency and

fairness of AI technology through the resolution of algorithmic bias and the development of explainable AI models should be further strengthened. The establishment of guidelines for securing data representativeness and algorithm auditing, as well as the advancement of technical methodologies such as XAI, should be pursued in parallel.

However, for such technical and institutional innovations to have a substantial effect, voluntary participation of companies and capacity building of civil society are of utmost importance. Efforts are needed to raise awareness and strengthen capabilities for the ethical utilization of AI by companies, expand citizen participation-oriented R&D, and enhance users' AI literacy. Fostering mutual trust and cooperation among stakeholders through open communication channels is crucial for ensuring the responsible development and utilization of AI technology.

7.2. AI-generated data management and quality control measures

As AI technology has a high dependence on data and its influence is wide-ranging, comprehensive management of training data and generated data is emerging as an important policy agenda. In particular, the preparation of quality control measures for the generation and distribution of reliable data is being raised as an urgent task more than ever.

For now, the introduction of a labeling system needs to be actively considered to suppress the generation of inappropriate or harmful content. A mechanism is needed to provide information necessary for users' judgment and choice and prevent deceptive acts by mandating explicit labeling of AI-generated content. However, side effects such as infringement of freedom of expression and shrinking creative activities due to excessive regulation should also be closely examined.

In addition, the construction of high-quality training datasets with minimized bias, discrimination, and privacy infringement is also an important task. In particular, technical research and institutional support are needed to secure representative data on socially marginalized and vulnerable groups, diagnose and correct data bias. The introduction of data construction through government-business-civil society cooperation, bias measurement tools, and data quality certification systems can be considered.

To increase the effectiveness of data supervision and control, the exploration of citizen participation-oriented data governance should also be pursued in parallel. Centering on areas where AI utilization has a significant impact, such as education, employment, and finance, measures can be considered to form a consultative body involving stakeholders to manage the entire cycle of data collection and utilization. Through this, the transparency and quality of data should be enhanced, and social acceptability and credibility should be improved.

7.3. Stakeholder cooperation for building a sound information ecosystem

After all, for an effective response to the rapid changes in the information environment caused by AI, joint efforts through cooperation and communication among various stakeholders are indispensable. As the benefits and risks of technological advancement are asymmetrically distributed throughout society, the

active participation and cooperation of each social entity and the balanced sharing of rights and responsibilities are being raised as more important tasks than ever.

First, the government should take the lead in establishing national-level AI policies and improving laws and institutions while performing the role of a coordinator of various interests. While strengthening the legal basis for AI technology regulation, such as enacting the National AI Ethics Framework Act and mandating data and algorithm impact assessments, promotion policies such as expanding AI public services and supporting AI utilization by small and medium-sized enterprises should also be pursued in parallel.

Companies should lead the responsible development and utilization of AI technology through the internalization of social ethics principles and the strengthening of self-regulation. The establishment of company-wide AI ethics policies, the development of explainable AI models, and the construction of ethical data collection and management systems are tasks that require companies' proactive practice. Efforts are also needed to ensure user privacy and choice along with the provision of transparent and fair AI services.

Civil society should raise its voice in monitoring and checking the social changes and impacts caused by AI while taking the lead in protecting the rights and interests of the socially disadvantaged and vulnerable. Monitoring and warning activities on human rights issues such as AI discrimination and privacy infringement, and legal support for victim relief should be strengthened. Furthermore, it should actively engage in education and promotion to improve public awareness and capabilities.

The media should take the lead in balancing the spotlight on social changes caused by AI and providing a forum for public discussion. It should lead healthy social discussions by enhancing understanding of the benefits and risks of technology and providing in-depth coverage of utilization status and issues. It should also contribute to expanding the role of the media and enhancing publicness through investigative reporting and data journalism utilizing AI technology.

Academia should contribute to seeking healthy interactions between science, technology, and society as a hub for empirical research and theoretical reflection on the social impact of AI. Empirical analysis of the benefits and risks of AI technology, exploration of the socio-cultural implications of AI based on the STS approach, and presentation of policy roadmaps can provide the knowledge base for policy formulation and social consensus building. **Figure 3** illustrates the proposed stakeholder collaboration governance model for a sound AI information ecosystem.

Thus, collaborative governance based on the roles and contributions of each social actor will be the key driver for creating a sound AI information ecosystem. Of course, there are many hurdles to overcome, such as establishing a foundation of trust and consensus for cooperation, adjusting mutual rights and obligations, and institutionalizing participation. However, it is clear that this is a task that must be tackled together to seek a path for sustainable technology-society co-evolution. Above all, when social solidarity consciousness and civic capacity aimed at the common good are backed up, the synergy of cooperation can also be maximized.

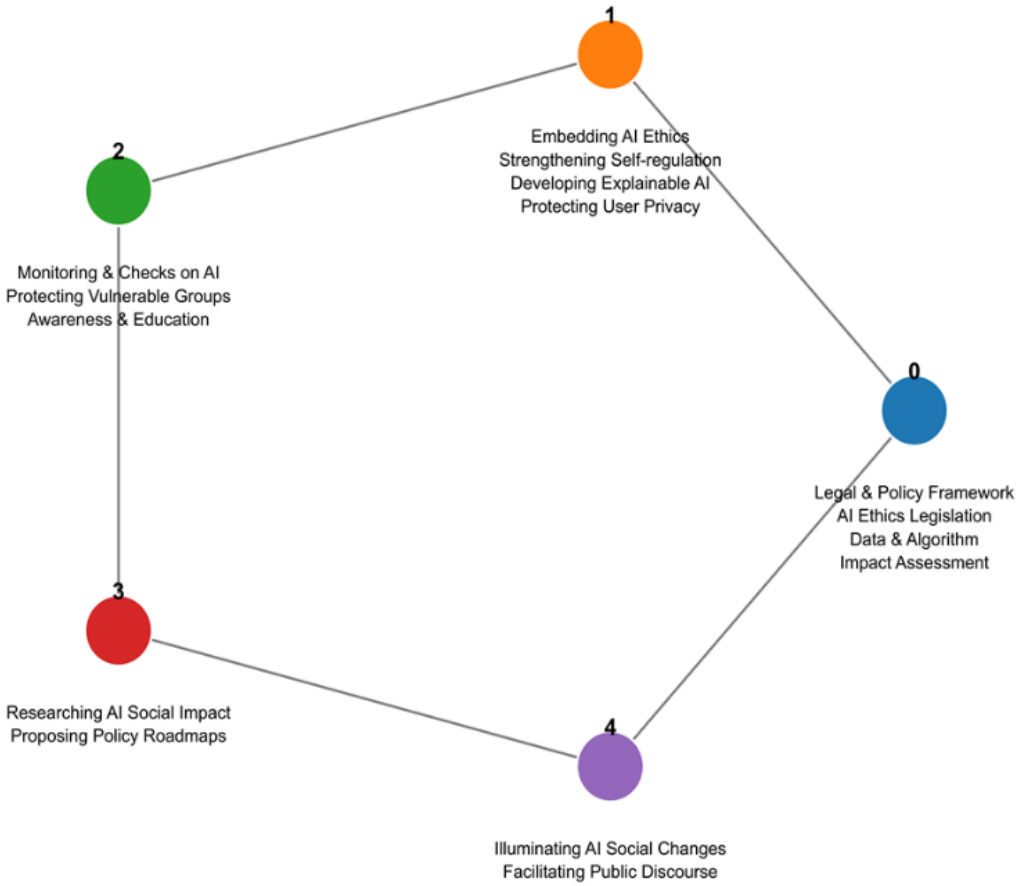

Figure 3. Stakeholder collaboration governance.

8. Discussion

This study aimed to diagnose the changes in the information environment caused by the rapid development of AI technology and explore countermeasures. Based on an overview of the current status and future prospects of technological development, a diagnosis of the limitations and challenges of technology, and an analysis of the impact on the information ecosystem, it sought to suggest a policy vision and tasks for responsible technology utilization and the establishment of a sound information environment. Synthesizing the analysis results, the following discussion is possible.

First, AI technology is advancing at an unprecedented pace through the advancement of data-based learning and reasoning capabilities, driving innovation across industries while fundamentally changing the everyday information environment. The performance improvement of component technologies such as natural language processing and computer vision, and the development of application services such as agents and metaverse, demonstrate that the impact of AI technology on society as a whole is growing. The results of expert interviews forecast that AI technology will surpass human capabilities in specific domains in the short term and evolve into human-level general intelligence in the long term. This is in line with existing research (Bostrom, 2018; Russell, 2022).

However, this outlook seems to be somewhat biased towards the technological aspect. In fact, current AI technology reveals various limitations such as bias, explainability, and generalizability, and it is difficult to ensure social acceptability

solely through the development of technology itself. In particular, the negative impact on the information environment and social repercussions receive relatively low attention compared to the technological innovation discourse. Efforts are needed to bring the speed and direction of technological development itself into the realm of social discourse.

Second, AI technology is causing extensive changes throughout the production, distribution, and consumption of information, and its impact is twofold. The analysis results showed that the explosive increase in AI-generated data and the advancement of personalized information services contribute to innovation in the information environment and the enhancement of user benefits, while also causing dysfunctions such as reduced information reliability, filter bubbles, and algorithmic discrimination. The possibility of information bias and distortion of public opinion due to platform monopolies, and the deepening of information gaps were also raised as problems that cannot be overlooked.

This suggests that the complex aspects of AI technology cannot be reduced to either optimism, which sees it as a mechanism for expanding information freedom and diversity, or pessimism, which is wary of it as a factor in deepening information control and surveillance (Zuboff, 2023). Beyond the characteristics and utility of the technology itself, it is necessary to note that socio-cultural conditions such as institutional control and usage context act as factors determining the direction of change. In short, the expansion of the social influence of AI technology in the era of information overload is an opportunity to accelerate the qualitative transition of the information environment and is emerging as a key variable determining the sustainability of a healthy information ecosystem.

Third, the problems in the information environment caused by AI technology at the current stage are difficult to resolve solely through self-regulation or market mechanisms and require policy intervention at the public level. The empirical analysis results confirmed that qualitative management of AI-generated information, prevention of bias, and protection of privacy require the parallel establishment of laws and systems and supervision at the government level, along with the voluntary efforts of companies. The results of expert opinion gathering also raised the need for policy measures to mitigate the social risks of AI technology and build trust.

This suggests that government policies should play a dual role as a facilitator of technological innovation and a coordinator of social repercussions. Related previous studies (Cath et al., 2018; Wallach and Marchant, 2019) have also emphasized seeking harmony between technology and society through the establishment of appropriate levels of regulation and governance systems. AI ethics guidelines, mandatory bias checking and disclosure of data, and AI literacy education were proposed as specific policy measures. However, rather than a rigid approach focused solely on regulation, a flexible combination of promotion and control, and measures to enhance effectiveness and acceptability through the participation and deliberation of various stakeholders should be sought.

Fourth, regarding the information imbalance and polarization of public opinion caused by AI technology applications such as chatbot journalism and personalized recommendation systems, strengthening users' critical awareness and subjective utilization capabilities along with technical solutions were raised as important tasks.

The survey results showed that while there was a coexistence of vague expectations and concerns about AI technology, passive and uncritical attitudes were found in the actual use of AI and the process of information utilization in real life.

This suggests that socio-cultural attitudes and utilization capabilities, rather than technology itself, may be the key factors determining the soundness of the information environment. Therefore, the enhancement of civic literacy, such as improving understanding of AI information services as a whole, raising awareness of data sovereignty, and training in active media use, needs to be highlighted as a policy agenda.

Fifth, policy tasks surrounding AI technology should be recognized as a holistic problem linked to the overall picture of social change, not an issue confined to a specific domain. This is because the social impact of AI is materializing in various areas such as industrial and economic issues like job replacement and economic polarization, political and social problems such as strengthened surveillance and control, and ethical issues such as infringement of dignity and autonomy.

As such, it is necessary to contemplate information problems from a macro and integrated perspective and strengthen policy linkages between sectors. Comprehensive policy design that seeks tension and harmony between technology-industry policies and socio-cultural policies, and between economic logic and ethical values is required. While utilizing the expertise of each domain, building a platform for communication, cooperation, and synergy creation between sectors will be the key. In short, at this important juncture, it is crucial to have a reflective attitude that seeks a path for the co-evolution of technology and society beyond optimism and pessimism about technological development, and to practice solidarity among various social actors.

Through the above discussion, this study sought to broaden the horizon of understanding regarding the interaction between AI technology and the information environment and contribute to presenting policy response measures. In particular, by illuminating related issues from various angles and supplementing empirical evidence, it aimed to expand the scope of academic discourse while contributing to providing basic data necessary for policy formulation. In addition, significance can be found in that it provided a starting point for expanding the horizon of related research by evoking the importance of convergent thinking encompassing technology, information, and society, and field-based prescriptions.

However, the limitations of the study include: first, given the rapid pace of AI technology development, the empirical data and analysis content of this study inevitably have a certain degree of temporality; second, due to the limitations of a purely theoretical approach, the arguments presented in this study lack empirical validation through research methods such as surveys or case studies; and third, the applicability to the domestic context was discussed while overlooking the context-dependence of overseas policy cases. Future research needs to track changes in perceptions of each actor from a long-term perspective, and seek ways to enhance policy effectiveness through analysis of usage behavior by type and cross-national policy comparisons. Additionally, empirical research methods, such as expert interviews, user surveys, and case studies, should be employed to provide concrete evidence for the theoretical arguments and to further validate the policy recommendations.

Above all, spreading awareness of the impact of AI technology on the information environment throughout society and activating citizen-led grassroots discussions remain important tasks. It is a point where the formation of a public sphere of reflection and solidarity is required, such as bridging the perception gap between technology-appropriating and marginalized classes, and providing a forum for communication to coordinate interests among users, businesses, and the government. Enhancing social imagination about technological innovation and strengthening citizen capabilities as information subjects will be the starting point and ultimate direction for realizing a sustainable information society. It is hoped that this study can serve as a catalyst for such discourse formation and practice.

9. Conclusion

The findings of this study shed new light on the complex interplay between AI technology and the information ecosystem, highlighting both the transformative potential and the challenges associated with the increasing integration of AI into the production, distribution, and consumption of information.

One of the key insights that emerged from the analysis is the dual nature of AI's impact on the information environment. On one hand, AI-driven innovations, such as personalized content recommendations and automated knowledge discovery tools, have the potential to enhance information accessibility and empower users in navigating the vast digital landscape (Arora and Scheiber, 2022; Li and Chen, 2024). These technologies can facilitate the discovery of relevant information, cater to individual learning needs, and promote a more engaging and interactive information experience.

On the other hand, the study also underscores the significant risks and challenges posed by AI in the information ecosystem. The prevalence of AI-generated misinformation, algorithmic bias, and privacy violations raises critical concerns about the reliability and trustworthiness of information in the age of AI (Nguyen et al., 2023; Silva et al., 2022). These issues are particularly acute given the increasing reliance on AI systems in shaping information flows and the lack of transparency and accountability in their design and deployment.

The findings contribute to the existing literature by providing a more nuanced and comprehensive understanding of the multifaceted impact of AI on the information ecosystem. While previous studies have examined specific aspects of AI and information, such as algorithmic curation (Anderson, 2020) or generative AI (Wang and Liu, 2023), this study offers an integrated analysis that considers the interplay between technological affordances, social implications, and policy challenges. By bridging disciplinary boundaries and incorporating insights from AI ethics, information studies, and policy sciences, the proposed analytical framework advances theoretical knowledge and provides a foundation for future research.

Moreover, the study highlights the need for a proactive and multi-stakeholder approach to governing the development and deployment of AI in the information ecosystem. The findings emphasize the importance of fostering collaboration among policymakers, industry actors, civil society organizations, and academia in addressing the challenges and harnessing the benefits of AI. This involves the development of

ethical guidelines, transparency standards, and accountability mechanisms that ensure the responsible and inclusive design of AI systems (Floridi, 2019; Gunkel, 2022).The study's theoretical significance lies in its innovative conceptual framework, which integrates the perspectives of technology, information, and society to understand the complex dynamics of AI-driven changes in the information environment. This framework provides a holistic lens for examining the interplay between technological development and social values, and for exploring the potential paths for the co-evolution of AI and society. The study's findings, which highlight the need for collaborative governance strategies and the importance of inclusive participation, transparency, and accountability, contribute to the growing body of knowledge on AI ethics and governance.

The practical implications of this research are far-reaching. The actionable insights and policy recommendations offered in this study can guide policymakers, industry leaders, and civil society organizations in developing effective strategies for harnessing the benefits of AI while mitigating its risks. The proposed multi-stakeholder framework for AI governance provides a roadmap for fostering a trustworthy and inclusive information environment in the era of AI. Furthermore, the study's emphasis on the role of citizens as active participants in shaping the future of information can inspire public engagement and dialogue on the social impact of AI.

In conclusion, this study makes significant contributions to the theoretical understanding of AI's impact on the information ecosystem and provides practical guidance for navigating the challenges and opportunities presented by AI-driven innovations. By bridging the gap between technology and society, this research lays the foundation for a more informed and nuanced approach to AI governance, one that prioritizes the values of transparency, accountability, and inclusivity. As AI continues to transform the landscape of information, it is crucial that researchers, policymakers, and society at large engage in ongoing dialogue and collaboration to ensure that the benefits of AI are harnessed for the greater good while its risks are effectively mitigated.

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