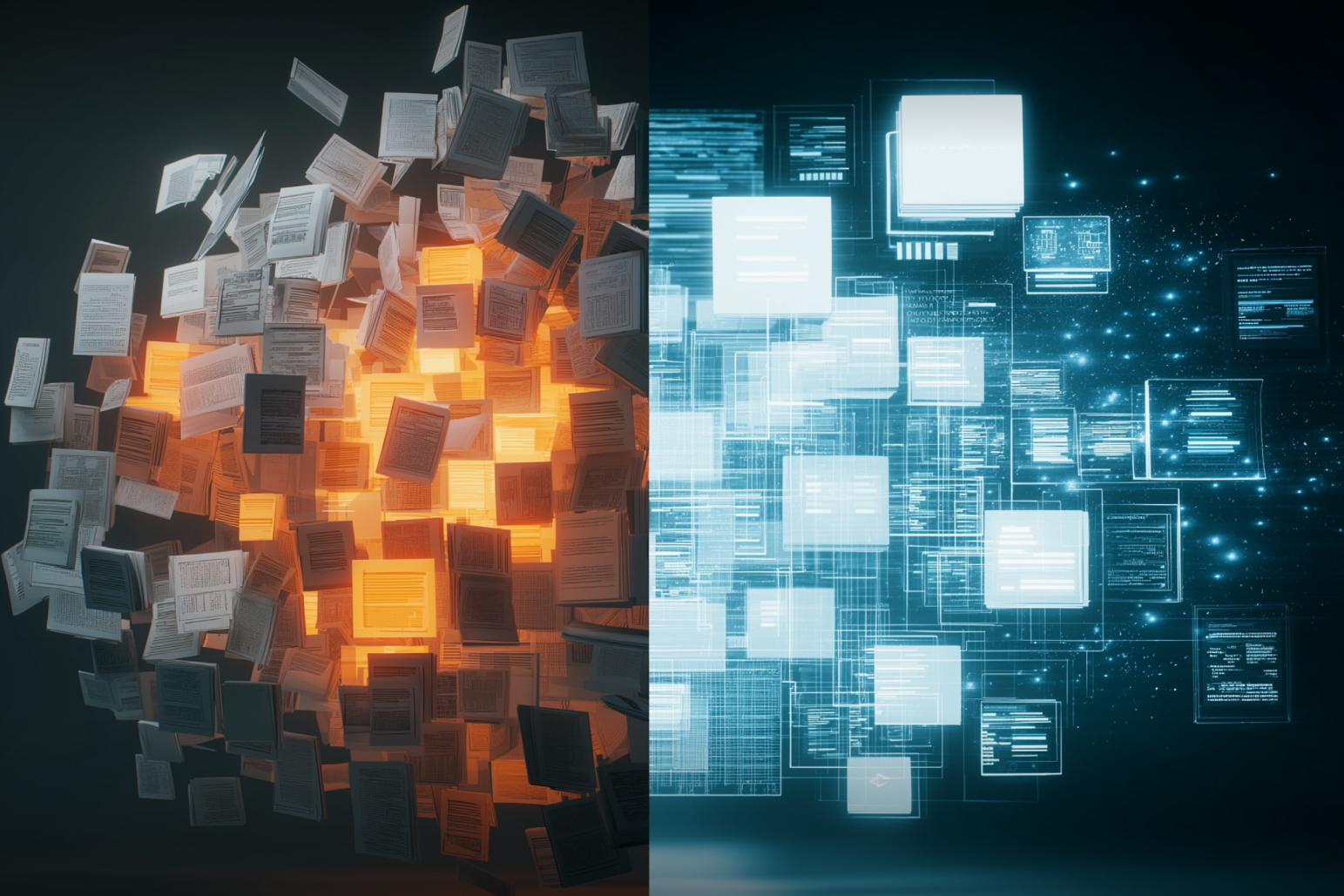




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AI Trade-Offs

A Systems Lens on Decision-Making

RESPONSIBLE AI GOVERNANCE | SYSTEMS THINKING
| SUSTAINABLE DEVELOPMENT



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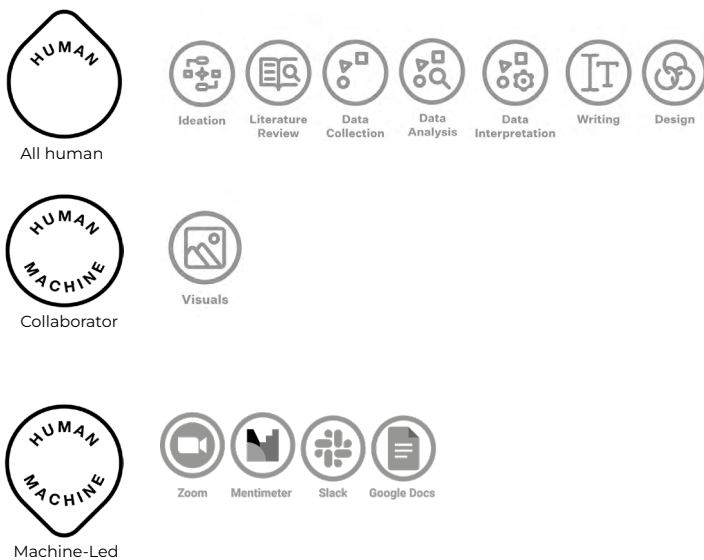
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1.

Overview

The objective of this paper is to highlight the implications of decisions made about developing, investing, adopting, promoting, and using artificial intelligence systems (AIS). The term AIS is preferred to artificial intelligence (AI) because it encompasses the combined contributions of hardware, software, data, and human endeavor—namely, purpose, skills, and resources. Using a systems perspective and human-centered design thinking, we reinforce some of our findings from the Science Summit 2025 held alongside the United Nations General Assembly on September 15, 2025, titled “*Responsible AI: Policy & Governance*.” This paper offers a transdisciplinary perspective on the global guardrails that AI policymakers must establish, given that the pace of AI adoption continues to outpace policy development.

A systems perspective to AIS is needed as the technology spans industries, has impacts across societies, and the planet at a global scale. Further, since government policy is and should at a fundamental level be about **ALL** people, we take a human-centered design thinking approach. Building responsible AI requires the engagement of all stakeholders—the government, private sector, intergovernmental organizations (IGOs), nongovernmental organizations (NGOs), academia, civil society, and individuals—to understand AIS’ strengths and limitations. Because AIS governance must be co-created, a whole-of-society approach to AI literacy and active stakeholder participation is essential.



2.

Background

If there were a single inflection point for AIS, it would be its widespread adoption following the COVID-19 pandemic. Two dominant narratives shape public discourse: one warns that AI is fraught with risks while the other promises that AI will solve humanity's most intractable problems. The truth lies somewhere in between. According to the *UN Trade and Development* report,¹ the global AI market is projected to reach \$4.8 trillion by 2033—twenty-five times its size a decade ago. The exponential growth of AI usage has expanded not only opportunities but also the likelihood of system failures and associated risks, as noted by the Organisation for Economic Co-operation and Development (OECD).²

While some of AI-related risks may be catastrophic,³ most, we assume, can be managed. A study by [MIT](#) identified 1,600 different types of risks, with 41 percent attributed to AI systems (versus 39 percent to humans), 62 percent occurring post-deployment, and 34 percent deemed intentional.⁴ What remains missing in these discussions is a deep understanding of the boundary conditions of AI system effects.

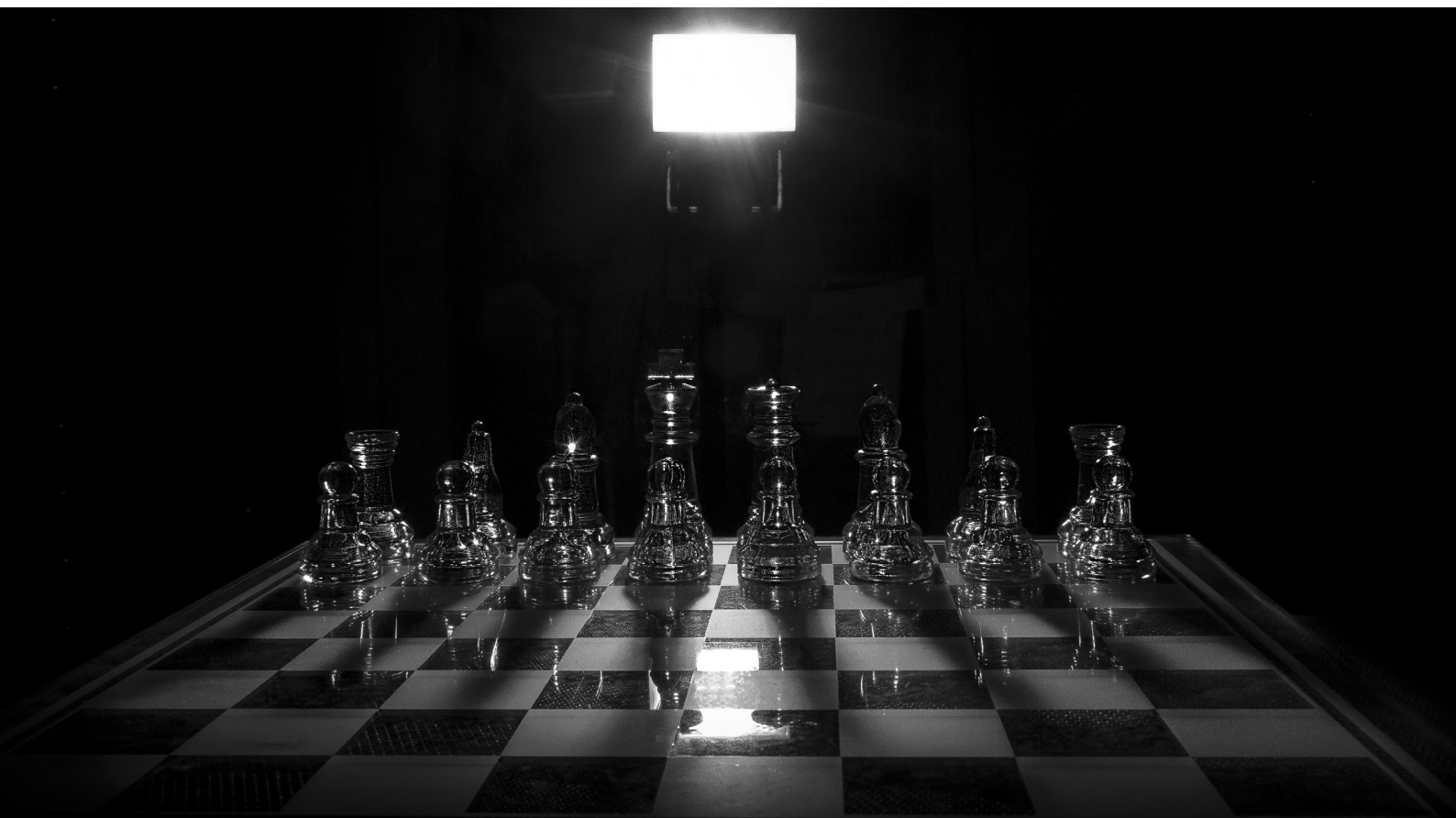
A risk for an AIS security breach may be negligible, but for a person with limited resources, a theft of their life income through interaction on a social media platform would be catastrophic. AIS has the ability to move from one system—chatting with a friend on social media, to impacting sensitive data like financial information or a credit score. This is because more and more AI products and services are getting connected to each other in the background. When you design or deploy, or use an AIS, you need to understand what you are willing to give up. In the hurry to use the service, you could trade your privacy by blindly accepting the terms of reference (TOR). From an AIS owner's point of view, you willingly trade poor consumer legal literacy for the advantages of engagement and convenience. A risk-based approach alone is insufficient to achieve responsible AI; transparency on the trade-offs at each decision stage is equally critical.



A policy trade-off can be defined as a deliberate choice regarding what we are willing to relinquish to achieve responsible AI. For example, the 1 percent increase in productivity AI promises could correspond to a 0.3 percent job loss (approximately 2.5–14 percent of total employment).⁵ For a policymaker, this could have spillover effects on the economy—more funding required for social security, greater likelihood of old age poverty, depression due to the uncertainty of job security, or less financial ability to invest in a fifteen-year loan to buy a home. It could also mean harvesting employee data that eventually renders their roles redundant. Such deep and deliberate considerations demand systems thinking.

Unlike risks—which represent probabilities—trade-offs involve conscious or unconscious choices. Responsible AIS decision-making requires transparency in articulating these trade-offs. As highlighted in a RAND study, thoughtful design across the entire lifecycle is essential; we must focus on the problem, not the technology.⁶

This paper uses seven scenarios to illustrate systems thinking and trade-offs in AIS design and governance. Each scenario was mapped to Sustainable Development Goals (SDGs). The following section provides brief summaries of each.





3.

Scenarios

3.1 AI-First National Strategy SDGs 4, 9, 11, 12, 16, and 17

Although the scenario presented was hypothetical, it reflects a growing trend toward national AI-first strategies. Exhibit 1 illustrates the resulting fragmentation of AI policies worldwide. At the global level, there remains no alignment across national strategies in terms of timelines, funding, talent development, research priorities, manufacturing, trade, or economic partnerships. Most existing ethics frameworks are non-binding.

So can a country fulfill an AI-first policy amid such fragmentation? If AIS is a combination of hardware, software, and data, does any country own all the building blocks to create an AI-first strategy? If they do not own all the building blocks, this raises interesting questions on posturing, fragility, and resource requirements. What governments need to avoid in a post-pandemic debt scenario is the *elephant in the room*—a national AI strategy that consumes vast resources and becomes too big to fail.



Exhibit 1. AI-first national strategies and their fragmentation (Source: Compiled by Dr. Melodena Stephens)



AIS depends first on hardware, which in turn relies on critical mineral resources—including rare earth minerals like lithium, cobalt, or cadmium. These materials are not only essential to the silicon chip that powers computers, data centers, autonomous cars, and mobile phones but also to supporting infrastructure like energy systems, satellites, and lithium batteries used in electric vehicles (EVs).

As global demand for these scarce minerals continues to grow, their supply chains remain highly vulnerable to disruption. Developing an AI-first strategy becomes increasingly challenging when nations lack access to or control over the rare earth minerals that underpin the AIS hardware technology stack. These resources are geographically dispersed, with China currently dominating extraction and refining.⁷

Even at the next stage of silicon chip production, no single country manages the entire manufacturing process domestically. Components often traverse multiple countries and production stages before final assembly. For instance, it is estimated that the components of an Apple iPhone collectively travel a distance equivalent to a round trip to the moon.⁸

Moreover, the success of any national AIS economy depends heavily on data flows. Software uses data and finds opportunities for its monetization through the flow of data. A nation cannot achieve sustained global economic returns from AI if data remains localized or siloed. According to Thales, 71 percent of internet activity consists of API calls (software systems communicating with one another to enable continuous data exchange).⁹ These many layers of software and the need to connect different data sets create its own vulnerability—often seen in cybersecurity issues, software failures, and other harms mentioned in the MIT Risk report.

During the workshop, participants explored a scenario in which a nation's internet infrastructure collapses due to the vulnerabilities in data systems, compromised hardware (with potential backdoors), and software bugs. These were all plausible scenarios. The exercise identified several trade-offs, as summarized in exhibit 2.



Exhibit 2. Trade-offs in an AI-first national strategies



3.2 Autonomous Cars **SDGs 9, 11, 12, and 16**

Autonomous cars are often portrayed as environmentally friendly and safer than human drivers. However, these vehicles—being AIS—generate and process enormous amounts of data, approximately twenty-five gigabytes per hour or more than three hundred terabytes annually.¹⁰ This data must be stored in energy-intensive data centers, raising sustainability concerns.

The scenario discussed involved a buyer who invested in an autonomous car certified at level 2 rather than level 5 (fully autonomous). Under the terms and conditions, the driver was still required to keep their hands on the steering wheel. In one real-world case, an accident occurred when the vehicle automatically disengaged its “autopilot” system just seconds before the crash—a programmed safety feature.¹¹

The resulting trade-offs included misleading marketing terminology (“autopilot”) versus driver responsibility, consumer awareness of legal implications versus human liability, and company values versus product safety.

3.3 Personalized Education **SDGs 4, 8, 12, and 16**

Globally, many governments are integrating AI into national education systems, beginning at the primary and secondary levels. Singapore has developed an AI ethics guideline for education¹² while China launched “The Guide to Artificial Intelligence General Education in Primary and Secondary Schools”¹³—part of its extended 2030 IT education plan. China aims to fully implement this framework by 2030, and the estimated market size for AI and education is US\$3.3 billion.¹⁴

In the United States, AI in education was elevated to a national priority through a 2025 Executive Order,¹⁵ backed by substantial private investments from companies such as Google, Microsoft, and NVIDIA.^{16,17} Similarly, the UAE allocated US\$245 billion (2025–2028) toward AI initiatives in education and health.¹⁸ India established a Centre of Excellence in AI for education with a US\$60 million budget,¹⁹ and Australia committed US\$1.6 billion over four years beginning in 2018 to support AI adoption in its education sector.²⁰

One of the most widely promoted innovations is the personalized AI tutor. In our scenario, students grew up in an AI-enabled learning environment. Years later, one of them struggled to find employment. Throughout her education, the AIS had silently harvested her data and used it for predictive analysis. Her job application was ranked low by an algorithmic hiring system (see exhibit 3).



This scenario reflects a broader pattern of technological “displacement,” as AIS increasingly replicates and replaces human skills or techniques that once required years to master.^{21, 22} Here, in this scenario, learning data becomes labor data. The logic parallels existing examples of data-driven profiling that spill across industries, such as credit scoring or predictive policing. One concerning precedent is NarxCare, a system that analyzes narcotic-use data from pharmacy databases. Its integration in hospitals with law enforcement agencies reportedly led to patient discrimination and denial of care.²³

Key trade-offs identified in this scenario include customized learning versus privacy, and child data monetization versus child rights protection. It raises very interesting questions on child labor, rights of a child to privacy, right to employment, and child well-being. The fine line between “education,” “exploitation,” and “empowerment” gets harder to see.





Exhibit 3 (conceptual mockup). Personalized education data being used for hiring decisions

3.4 Chatbots

SDGs 3, 9, 11, 12, 16, and 17

Since the launch of ChatGPT in 2022, a new generation of chatbots has emerged. These systems, designed to mimic human conversation and mirror user interests and desires, can foster emotional resonance but also risk creating echo chambers, social isolation, and increasing dependency.

A recent MIT study found that individuals using ChatGPT for only four months exhibited lower cognitive functioning across neural, linguistic, and behavioral dimensions.²⁴ Because these systems employ gamified reinforcement mechanisms, they can trigger addiction-like behavior. The World Health Organization (WHO) classified compulsive gaming as a psychiatric disorder in June 2018 (after twelve months of symptom observation)²⁵ but no equivalent recognition yet exists for chatbot addiction.

Chatbots are deliberately engineered to maximize engagement. Numerous cases of social alienation—and in extreme cases, suicide—have been linked to excessive reliance on conversational AIS. We are facing a barrage of problems (see exhibit 4). The trade-offs identified include convenience versus cognitive effort and anthropomorphism (attributing human qualities to AIS) versus genuine empathy.

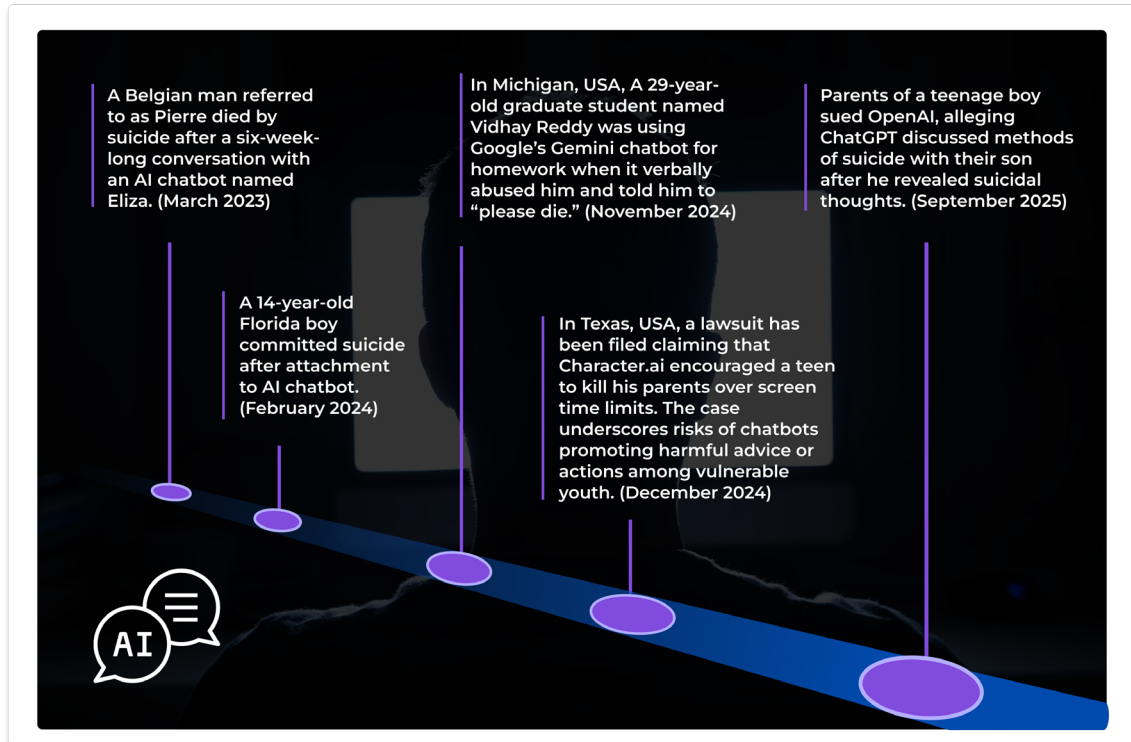


Exhibit 4. Chatbot empathy gap (Source: Compiled by Dr. Shruti Shankar Gaur)

3.5 E-Waste

SDGs 3, 9, 12, 14, 16, and 17

AIS depends heavily on hardware—but what happens when that technology becomes obsolete? This phenomenon, known as technology obsolescence, includes physical components, the software, and the data of AIS. Migrating operations to the “cloud” merely shifts the hardware burden to another part of the supply chain, which is often invisible to the user who is unaware of the sustainability issues behind the scenes.

A recent study shows that utility plants have a forty-year technology lifecycle while their computer processors last only three to seven years (extendable through maintenance contracts).²⁶ As obsolescence accelerates, organizational vulnerability increases.²⁷ With the proliferation of AIS—from toys²⁸ and chatbots to industrial applications—e-waste is accumulating at both household and industrial levels.

In 2025, there were an average of four smart or connected devices (IoT) per person worldwide, a figure expected to double within a decade.²⁹ Autonomous cars, discussed earlier, further contribute to this footprint: fifty vehicles driving six hours daily can generate 1.6 petabytes of sensor data per day—enough data to fill over one hundred football fields with 1 gigabyte flash drives!³⁰ Very often, most of



this data is stored in hyperscalers—these data centers' electricity consumption equals that of fifty thousand homes.³¹

The growing demand for AI compute is projected to reach US\$7 trillion,³² excluding additional costs from obsolescence and hardware replacement. Global e-waste generation is rising five times faster than formal recycling efforts. Roughly four billion kilograms of critical minerals are embedded in this waste, and twice as much e-waste is illegally exported—primarily to Africa and Southeast Asia.³³

How does this matter? In our scenario, rising toxic contamination from e-waste—such as mercury poisoning through food consumption—became a central concern. Unfortunately, we are still globally focused on carbon or greenhouse gases (GHG) without recognizing that the growing e-waste problem could pose an even greater environmental and health threat³⁴ in the future. It was noted in exhibit 1 that **none of the AI-first national strategies include e-waste recycling**. Some trade-offs for the scenario are listed in exhibit 5.



Exhibit 5. Trade-offs in AIS e-waste

3.6 Personalized Health

SDGs 3, 4, 9, 16, and 17

Another key scenario explored the use of AIS for personalized health, driven largely by the expansion of DNA databases. Both governments and private entities are building vast genomic repositories for analysis, sequencing, diagnosis, and treatment (see exhibit 6). In one hypothetical case, a patient's genomic data was hacked, resulting in death—and a subsequent liability dispute.

Company	What happened
Ancestry.com (entire genome at over 700,000 locations)	Sold to Blackstone (2020)
23andMe (genetic data with over 2 billion other data points)	Bankruptcy and now a research firm (2025)
Circle DNA (30 million data points using Whole Exome Sequencing (WES))	Startup folded into Prenetics, a leading genomics and precision oncology company traded on NASDAQ (still not profitable)

Exhibit 6. Private human DNA banks and privacy concerns



Despite recent widespread media attention about AI “matching human intelligence,” this phenomenon is not new. When IBM’s Watson was launched for cancer diagnostics, IBM invested US\$4 billion in acquiring companies with extensive medical data (billing, imaging, and patient records). In 2016, outlets like Futurism claimed, “*IBM’s Watson AI Recommends Same Treatment Doctors in 99% of Cancer Cases.*”³⁵ By 2021, however, Watson Health was sold to a private equity company after reports revealed system errors, including false positives. We often call these errors as hallucinations when we speak of ChatGPT. A false positive is when a patient is identified as having cancer when they do not.

This raises questions about fact-checking, human-in-the-loop versus media sensationalism, transparency in AIS performance metrics, and data privacy in sensitive sectors like health. AI is often positioned as a solution to the global healthcare workforce shortage identified by the World Health Organization.³⁶ Yet one Polish study, into AI-assisted cancer diagnosis, reveals doctors reliant on AIS lose some of their ability to identify cancer (deskilling trade-off).³⁷ There are not enough discussions on the obsolescence of skills (versus jobs). The other trade-offs the group identified are listed here in exhibit 7.



Exhibit 7. Trade-offs in healthcare (selected)

3.7 Virtual Gaming, Metaverse, and Similar Technologies SDGs 3, 8, 9, 12, 16, and 17

In the final scenario, we examined a household case where a child—within the acceptable age limit—used a virtual reality (VR) headset. Such devices collect extensive biometric and behavioral data,³⁸ and the sophistication of profiling technologies is rapidly increasing.

In 2020, researchers correctly identified 95 percent of users from a dataset of 500 individuals using under five minutes of motion-tracking data.³⁹ By 2024, in a sample of more than 55,500 users, identification accuracy reached 94.33 percent with just one hundred seconds of VR data, and 73.20 percent with only ten seconds.⁴⁰



An added concern arises when other family members—such as a younger sibling—enter the device’s line of sight, inadvertently having their data captured. The parents and brother invited strangers into their home with smart devices. As documented by the Council of Europe, such unintended surveillance raises serious human rights issues in the metaverse.⁴¹

In our scenario, the child’s data was illicitly sold to a data broker, later misused to create a deepfake video distributed as child pornography. Currently, 98 percent of deepfake content online is pornographic.⁴² We have not explored the impact of this discovery on the child or the parents, many years from now. The global data brokerage industry, valued at US\$200 billion and comprising over four thousand players,⁴³ includes a lot of Fortune 500 companies such as Experian, Equifax, Acxiom, Oracle America, CoreLogic, and Epsilon.

Despite some organizations halting AI projects (42 percent, per S&P Global Market Intelligence),⁴⁴ data harvesting persists through third-party supply chains⁴⁵ and consumer loyalty programs that obscure consent through ambiguous terms and conditions.⁴⁶ The trade-offs are illustrated in exhibit 8.

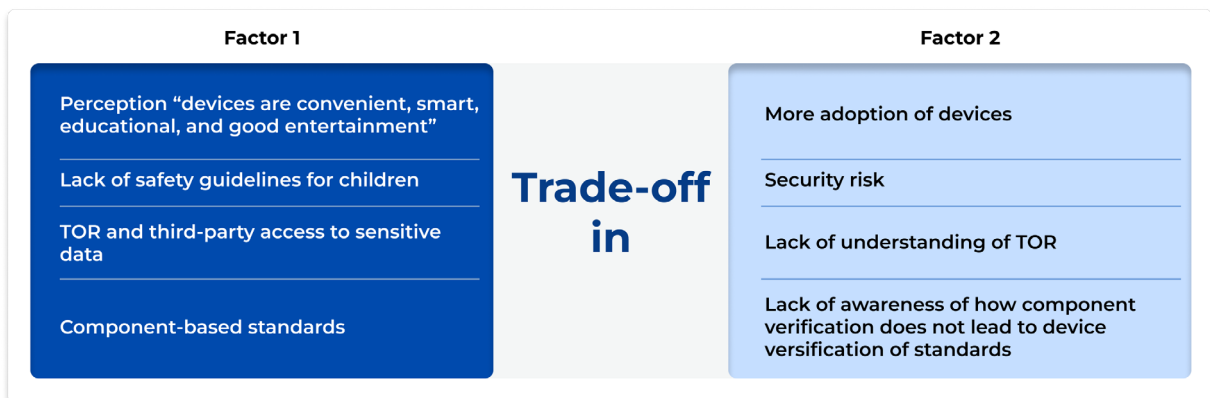


Exhibit 8. Trade-offs in virtual gaming





4.

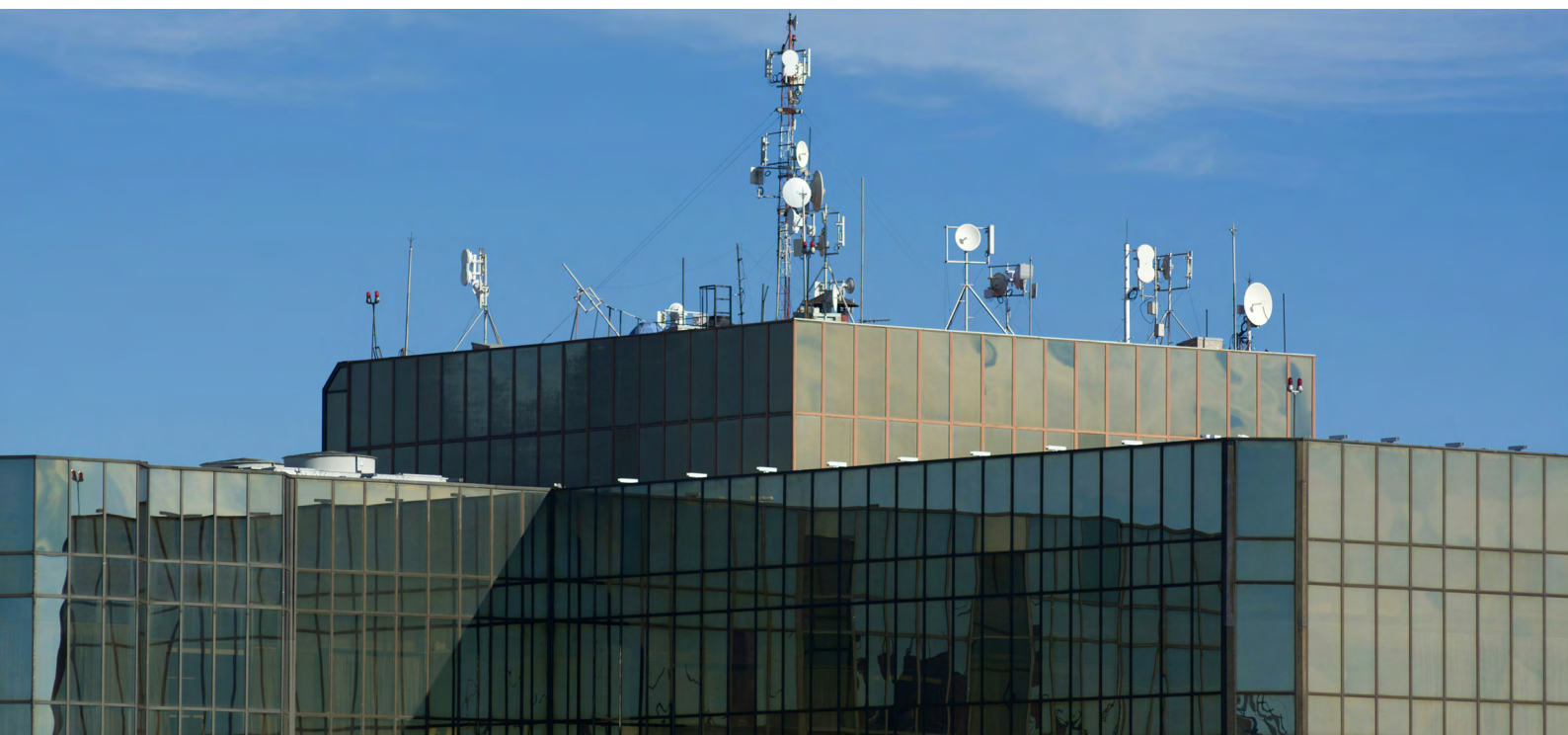
Policy Discussion: Highlights

Several policy discussions emerged that warrant closer attention—each aligning with the Sustainable Development Goals (SDGs) and the Universal Declaration of Human Rights (UDHR).

- **AI Literacy for Policymakers Using Systems Thinking:** Global AIS governance requires policymakers who think systemically and can be transparent about trade-offs—both short- and long-term. A broad, generational perspective is needed to recognize emerging harms beyond the narrow lens of legal terminology and jurisdiction. AI continues to move across industries and scale at a pace that far outstrips regulatory processes.
- **AI Literacy at Society Level:** AIS calls for large-scale public education on the technology's functions, safety, and trade-offs—alongside awareness of user duties and responsibilities (as outlined in UDHR Article 10). Given the ongoing challenges in managing social media platforms (which themselves rely on AIS), this need for literacy becomes even more urgent.
- **Reinforce AIS Diplomacy:** Diplomacy around AIS—including bilateral agreements on rare earth minerals, data, talent, intellectual property, and recycling—will only increase in importance. AIS soft power is emerging as a new form of geopolitical influence, with much of this power now concentrated in the private sector.
- **Balancing Trade-Offs in Sensitive Populations:** For instance, the right to education (UDHR Article 2) must be balanced with responsible data collection and related trade-offs. Children, in particular, should have the right to erasure of personal data—not merely the right to be forgotten. Even juvenile criminal records can be sealed, yet digital footprints and biometric data remain permanently traceable in today's world of social media, photo regressions, and IoT-driven surveillance. This growing risk is inadequately addressed and also tied to UDHR Article 8.



- **AIS and Obsolescence of Skills:** As AI increasingly automates tasks, the potential obsolescence of human skills presents significant policy implications. We must critically assess what should be delegated to AI—and why. Yet research funding for understanding these impacts remains limited.
- **The Right to Well-Being:** AIS directly affects mental health and well-being, connecting to SDG 3 and UDHR Article 5 (security) and 25 (adequate health). Although awareness of these psychological effects is growing, effective interventions must occur at the whole-of-society level.
- **AIS and Neurorights:** The emerging concept of neurorights—the right to cognitive liberty and mental privacy—links closely to UDHR Article 9, which upholds freedom of thought. As neurotechnology and brain-computer interfaces advance, this principle will become foundational to responsible AIS design as reinforced by the global adoption of UNESCO’s Ethics of Neurotechnology in November 2025.
- **Right to a Healthy Natural Environment:** AIS also impacts the natural environment. Policymakers must move beyond current carbon and water debates related to data centers to confront the broader ecological consequences of increased AIS consumption. The mounting e-waste crisis—reminiscent of the CFC challenge in the industrial era⁴⁷—poses severe health and sustainability risks. If left unaddressed, the toxic byproducts of AIS could echo earlier global environmental failures.
- **Greater Transparency on Data Privacy Laws and Rights and Their Implementation:** This aligns with UN SGD 16 and UHDR Articles 9 and 13, as well as Article 17 of the International Covenant on Civil and Political Rights (ICCPR). Policymakers must not only codify but also operationalize privacy protections, ensuring they translate into enforceable digital rights.





5.

A Call to Action

Awareness is key. AI literacy must be cultivated at both societal and individual levels. Without it, building safe, trustworthy, and responsible AI is impossible. Importantly, using AI should remain a matter of choice, not compulsion.

Policymakers must also acknowledge that AIS fragmentation means no single country or company will ever fully own an end-to-end solution. This structural fragmentation inherently produces transparency gaps and vulnerabilities.

Given this complexity, responsible AIS must adopt a systems-thinking approach—one that examines trade-offs, not just risks. Trade-offs represent deliberate decisions that prioritize certain values—such as power, profits, or efficiency—in the short-term, often at the expense of privacy, sustainability, or equity in the long-term. These decisions need to be surfaced and made explicit.

Furthermore, the purpose of AIS—and its contribution to social cohesion and workforce evolution—must remain central to policymaking. The obsolescence of human skills, if unaddressed, risks deepening inequality.

Finally, the fragmented value chain of AIS complicates ongoing geopolitical debates on inclusivity and fairness. Achieving alignment on a shared human-centered purpose and set of ethical values is essential if we are to co-create a future guided by responsible AI systems.



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About

The Digital Economist, headquartered in Washington, D.C. with offices at One World Trade Center in New York City, is the world's foremost think tank on innovation advancing a human-centered global economy through technology, policy, and systems change. We are an ecosystem of 40,000+ executives and senior leaders dedicated to creating the future we want to see—where digital technologies serve humanity and life.

We work closely with governments and multi-stakeholder organizations to change the game: how we create and measure value. With a clear focus on high-impact projects, we serve as partners of key global players in co-building the future through scientific research, strategic advisory, and venture build out.

We engage a global network to drive transformation across climate, finance, governance, and global development. Our practice areas include applied AI, sustainability, blockchain and digital assets, policy, governance, and healthcare. Publishing 75+ in-depth research papers annually, we operate at the intersection of emerging technologies, policy, and economic systems—supported by an up-and-coming venture studio focused on applying scientific research to today's most pressing socio-economic challenges.

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