

# ERGONOMICS AND THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE SUSTAINABLE DEVELOPMENT OF THE SOCIO TECHNOGENIC WORLD

*Razzokov Xabib Kholikovich* - Associate Professor of the Department of “Labor Protection and Health Engineering” at Samarkand State University of Architecture and Construction

*Ashurov Islomiddin* - 1st year Master’s student of the Department of “Labor Protection and Health Engineering” at Samarkand State University of Architecture and Construction

**Article information:**

**Manuscript received:** 12 Oct 2025; **Accepted:** 13 Nov 2025; **Published:** 30 Nov 2025

**Abstract:** This paper provides an exploratory study of the theoretical, methodological, and practical integration of ergonomics and artificial intelligence. This research explores the potential adverse human system interactions and those functions that AI can perform in regard to ergonomic design, risk management and ethical norms (the human in the loop principle), as well as the mechanisms that can put this integration into action within national strategies and legislation of the Republic of Uzbekistan. This information can be found in the article, which includes scientific models and formulas as well as a table of indicators to monitor. Supporting sources for all key claims and recommendations are provided as in-text references using a numerical system

**Keywords:** ergonomics, artificial intelligence, sustainable development, human centered design, AI (Artificial Intelligence, ethics, legislation of Uzbekistan, monitoring indicators.

## Introduction

The twenty first century is witnessing a huge impact from artificial intelligence as well as digital technologies on the change of modern socio technogenic systems. Although they drive automation, digitization, and value propositions, these changes can change human physical and cognitive load and raise relevance of social equity and environmental sustainability [1]. This is where ergonomics is a crucial element, necessarily geared at developing technologies that respect human capabilities and never stray too far from the way humans actually work. This alignment is further enhanced by AIs ability to quickly analyze data and provide personalized, end user focused assistance.

At policy level these developments are strengthened in Uzbekistan with the “Digital Uzbekistan 2030” strategy the follow-up, national initiatives of AI, establishing legal and institutional conditions for ergonomics AI integration [2]. At the same time, international frameworks including those from UNESCO, OECD and ISO also provide vital reference points for shaping national pathways.

This paper provides a vision of scientific and practical means by using synergetic action of ergonomics and AI for the development of sustainable socio technogenic systems.

There was a gradual and evolutionary nature to human interaction with the natural environment, however, from the Neolithic to the Industrial Revolution human pressure on the biosphere increased alongside the expansion of the technosphere creating novel anthropogenic pressures on ecological homeostasis [3]. It is this change that Demidenko and others see as the beginning of a post biospheric time that "will need new products, new ways of thinking that allow them to be sustainable on a very very long term" Notably in this context, human centered design (ISO 9241–210) is rapidly becoming a prerequisite in AI projects, requiring transparency, accountability, and human rights [4]. This calls for

alignment of AI with ergonomic principles, as seen in the ethical guidelines from UNESCO and OECD.

**Methodology.** This study employed various complementary methods. This review was completed via documentary analysis of national strategies, legal frameworks, and international standards regarding ergonomics, and artificial intelligence. Through a theoretical literature review insights were gained regarding ergonomics, human factors and AI ethics, which formed the conceptual basis for the research. Calculative and indicative modelling were used to create analytical systems such as models of ergonomic efficiency and a sustainable development index. Furthermore case study analysis was used to analyze practical examples and provide policy suggestions to improve ergonomics and AI integration.

The following models were proposed in the study:

Model 1 — General Ergonomic Efficiency (E):

$$E = \alpha H + \beta T + \gamma S$$

where:

H — Human Load Index (HLI);

T — technology adaptability (AI<sub>eff</sub>);

S — socio legal environment;

$\alpha, \beta, \gamma$  — weighting coefficients.

Model 2 — Sustainable Development Index (Q<sub>sust</sub>):

$$Q_{sust} = \frac{H_s \times AI_{eff}}{R_{env} + S_{risk}}$$

Here: H<sub>s</sub>— human safety coefficient;

R<sub>env</sub>— environmental risk;

S<sub>risk</sub>— sociotechnical risks.

These formulas show that achieving sustainability requires not only increasing AI efficiency but also reducing environmental and social risks [5].

**Monitoring and indicators.** In practice, the following indicators are recommended for monitoring and evaluation (Table 1):

Table 1. Main monitoring indicators

No	Indicator (Code)	Unit of Measurement	Target Value
1	HLI (Human Load Index)	%	60–70
2	AI <sub>Err</sub> Rate	errors/1000 op	≤ 5
3	RT (Reaction Time)	ms	≤ 250
4	USI (User Satisfaction Index)	1–10	≥ 8

№	Indicator (Code)	Unit of Measurement	Target Value
5	EnvRiskIndex	0–1	$\leq 0.3$
6	SR (Safety Ratio)	0–1	$\geq 0.9$

These indicators must be empirically measured in pilot projects in alignment with ISO and GOST standards.

The entire legal and strategic umbrella of Uzbekistan is governed under the strategy of the Digital Uzbekistan 2030, which aims to rapidly digitize all fields imaginable: from public administration and education to healthcare and even the industry [6]. Accordingly, the strategy pinpoints the segments of workforce development and the establishment of an innovation ecosystem as priority means. The national AI development strategy (Presidential decree) 2024 builds on this foundation and defines plans on establishing a national AI ecosystem, developing national AI models, and enhancing professional training in the area [7][8].

In accordance with the Law «On Environmental Protection» [9], it is needed to reduce potential ecological hazards and to assess the impact on environment when implementing AI-related projects. The Labor Code prescribes ergonomic requirements for work places and imposing safety obligations on employers, an important consideration when automizing [10].

ISO 9241–210 Human centered design standards, which have been recommended by UNESCO and OECD serve as border approaches to design the national regulation; therefore, Uzbekistan can elaborate on these documents and formulate own national standards and regulatory codes [11].

Real world experience: Cases of integration in practical sectors.

One might argue that Predictive maintenance models could help improve MTBF and accident risks given but a poor operator screen design may cause more cognition overload and increased error rates. This leads to a core task in ergonomics, optimizing interface design layout, clarity of signals and essence of visual information [12].

Intelligent Transport Systems (ITS) reduce traffic risks effectively, but it has been shown that the ergonomic quality of the designs of dispatcher and operator interfaces is a critical factor for the success of RT and HLI indicators. These ergonomic opportunities are now being investigated within the urban pilot projects on traffic monitoring in Uzbekistan [13]. CDSS assist physicians with quick and precision recommendations but the responsibility of the final decision always has to be with the clinician, an ethical and ergonomic obligation. For CDSS tools, usability testing and cognitive walkthrough techniques are mandatory measures to be used before deployment.

Adaptive learning platforms offer content tailored to the cognitive and motivational states of students; interface ergonomics for instructors is competing [14]. This is a national priority, high up on the agenda — especially with the launch of the strategy “Digital Uzbekistan — 2030”

Transparency, fairness, human dignity and accountability continue to be steadfast principles in the implementation of AI (UNESCO, OECD). National legislation should operationalize these principles by providing mechanisms to ensure accountability for automated decision

making [15].

This analysis of the literature and other sources establishes the basis from which a number of recommendations can be made. Uzbekistan must establish a national “AI–ergonomics” standard in accordance with the sectors ISO and GOST, which will provide, inter alia, the use of such indicators as HLI, RT, USI and EnvRisk. The principles of human-in-the-loop and human-on-the-loop need to be formally embedded within legislation, coupled with strict regulation on the attribution of liability for automated decisions. Another important measure is to create an AI audit system and certification system, with transparency in audit reports (expect different levels of public access to such audits). It could be embedded into higher education and professional training programs, while pilot studies in industry, transport and healthcare need secure funding. Future directions consist of empirical monitoring (HLI and AI\_ErrRate in real workplaces), modeling local coefficients ( $\alpha$ ,  $\beta$ ,  $\gamma$ ), AI risk assessment based on FMEA and FTA, and measurement of cognitive fatigue using surveys and neurobiomarkers. Research on ethical and legal aspects should target the specification of responsibility models for automated decisions systems [16].

### **Conclusion.**

Finally, the introduction of ergonomics and artificial intelligence is an effective tool for sustainable development. This approach is endorsed by national strategies for Uzbekistan, but there are several other complementary actions needed to ensure effective implementation. National AI–ergonomics standards and a robust audit system will have to be manufactured to ensure transparency and safety. To uphold user rights and accountability, legislation needs to clarify human-in-the-loop principles or better yet, clarify who is responsible for automated decision making. AI ergonomics modules need to be included in higher education and professional retraining programs if we want to have qualified specialists who will be able to manage the technological systems of the future. Furthermore, empirical monitoring via small pilot projects in strategic sectors should also be undertaken to lay the groundwork for wider, deliberate scaling. The sequence of these steps aims to ensure that the AI technologies will be introduced at a stage that allows for protection of human wellbeing, the enhancement of institutional reliability and upholding of the long-term sustainability of sociotogenic systems.

### **References**

1. Thatcher A. and Yeow P. H., “Human factors for a sustainable future,” *Applied Ergonomics*, 2016.
2. O‘zbekiston Respublikasi, *Raqamli O‘zbekiston – 2030* (PF-6079).
3. Demidenko E. S., *Noospheric Ascent of Earthly Life*. Moscow: URSS, 2003.
4. ISO, *ISO 9241–210:2019 – Human-Centred Design for Interactive Systems*, 2019.
5. Lepsky V. E., “Philosophical and methodological foundations for improving digital transformation and introducing AI,” *Philosophical Sciences*, 2022.
6. UNDP, *Sustainable Development and Digital Transition Report*, 2024.
7. Dergacheva E. A., *Socio-Technonatural Globalization: Interdisciplinary Analysis*. Moscow: URSS, 2016.
8. O‘zbekiston Respublikasi, *President Decree RP-358 (14.10.2024): Strategy for the Development of Artificial Intelligence Technologies until 2030*.
9. Moray N., “Culture, politics and ergonomics,” *Ergonomics*, 2000.

10. O‘zbekiston Respublikasi, *Mehnat Kodeksi* (Revised Edition, 2022/2023).
11. Garcia-Acosta G., *La Ergonomía Desde la Visión Sistémica*. Universidad Nacional de Colombia, 2002.
12. UNESCO, *Recommendation on the Ethics of Artificial Intelligence*. Paris, 2021.
13. OECD, *Principles on Artificial Intelligence*. Paris, 2019.
14. Hancock P. A., “Automation: How much is too much?” *Ergonomics*, 2013.
15. EU Commission, *Ethics Guidelines for Trustworthy AI*. Brussels, 2019.
16. O‘zbekiston Respublikasi, *Atrof-Muhitni Muhofaza Qilish To‘g‘risida Qonun* (2021).