Alina Yakymchuk
Professor, Doctor of Economic Sciences,
University of Information Technology and Management, Poland;
Kherson State Agrarian and Economical University, Ukraine
Russell Matia Woruba
Department of Information & Communication Technology,
Port Moresby, Papua New Guinea;
University of Information Technology and Management, Poland

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INFRASTRUCTURE RESILIENCE AND ARTIFICIAL INTELLIGENCE IN ADDRESSING GLOBAL CLIMATE CHALLENGES ACROSS ECONOMIC SEGMENTS

Introduction. Global climate change represents a multidimensional challenge that increasingly affects economic systems, social stability, and ecological security. The vulnerability of economic segments – such as energy, transport, agriculture, and industry – is directly linked to the resilience of their infrastructures and the degree of technological adaptation. Artificial intelligence (AI) is becoming a key transformative instrument in mitigating climate threats by optimizing resource use, predicting risks, and supporting evidence-based policy decisions. This paper explores the intersection between infrastructure resilience and AI-driven climate responses within different economic sectors, emphasizing the potential for systemic adaptation and sustainable development [1].

The intensification of global climate change has led to unprecedented disruptions in natural and economic systems [2]. Floods, heatwaves, wildfires, and droughts now cause substantial losses to infrastructure, supply chains, and human settlements. These impacts vary across economic segments, revealing inequalities in adaptive capacity and access to innovation [3]. Infrastructure resilience – the ability of physical and institutional systems to absorb, recover, and adapt to shocks – has emerged as a strategic priority of climate governance. At the same time, artificial intelligence (AI) technologies are revolutionizing climate analytics, predictive modeling, and early warning systems, creating new opportunities for cross-sectoral sustainability [4].

Main part. Each economic segment experiences climate threats differently:

– Energy sector: faces increased risks from extreme weather events that disrupt production and transmission. Renewable infrastructure requires intelligent forecasting to ensure stability.

– Transport sector: vulnerable to sea-level rise, road degradation, and extreme temperature fluctuations. AI-enabled monitoring supports predictive maintenance and reduces emissions.

– Agriculture: suffers from droughts and soil degradation. AI-driven data systems improve irrigation management, crop planning, and climate adaptation strategies.

– Industry: faces pressure to decarbonize while maintaining competitiveness. Intelligent manufacturing and green infrastructure investments enhance resilience.

– Urban systems: concentration of people and infrastructure amplifies risks. Smart city solutions based on AI improve waste management, energy efficiency, and climate monitoring.

This segmentation highlights that climate resilience must be both sector-specific and systemically integrated. Resilient infrastructure represents the foundation of climate security [5; 6]. It ensures continuity of critical services – energy, water, communication, and mobility – during and after climate events. However, traditional approaches to infrastructure planning are insufficient in a rapidly changing climate. Future-oriented infrastructure must be [7; 8]:

1. Modular and adaptive – capable of evolving with technological and environmental conditions;

2. Digitally integrated – combining sensors, AI, and big data to predict vulnerabilities;

3. Environmentally sustainable – minimizing ecological footprint and maximizing ecosystem services.

Such transformation requires coordinated investment, governance innovation, and knowledge transfer across borders [8]. AI contributes to climate resilience through several core functions: predictive modeling: simulating the impacts of climate scenarios on different economic segments; decision support systems: optimizing infrastructure investments and disaster response; automation and efficiency: improving energy use, logistics, and industrial production; risk communication: facilitating rapid information flows to policy-makers and citizens.

AI also enables climate intelligence networks – systems that combine satellite data, machine learning, and local knowledge to enhance monitoring and adaptive planning. Nevertheless, the integration of AI into climate policy raises ethical, security, and equity concerns. Ensuring transparent algorithms and inclusive data access remains essential [9]. Climate-resilient development must align infrastructure investment with technological innovation and social inclusion. Key policy directions include: integrating AI-driven risk assessment into national infrastructure planning; establishing global data-sharing frameworks for climate modeling; promoting public–private partnerships for green innovation; supporting education and workforce reskilling for AI and climate resilience; encouraging international cooperation to reduce technology gaps among economic regions (Tab. 1).

Table 1

Comparative Analysis of Economic Segments: Climate Threats, Infrastructure Resilience, and AI Integration

Economic Segment	Major Climate Threats	Infrastructure Vulnerability	AI Application Potential	Examples of AI-Based Solutions
Energy	Extreme weather events, heatwaves, disruption of renewable generation	High – due to centralized grids and aging transmission systems	Very high	Smart grids, AI-based demand forecasting, optimization of renewable energy mix
Transport	Floods, sea-level rise, temperature extremes damaging roads and rail	High – critical dependence on continuous physical networks	High	Predictive maintenance, AI-driven traffic management, emission optimization
Agriculture	Droughts, soil erosion, crop failure, pest outbreaks	Medium to high – climate-sensitive production systems	Very high	Precision agriculture, AI irrigation control, crop disease detection
Industry and Manufacturing	Energy price volatility, supply chain disruptions, emissions constraints	Medium – dependent on energy and logistics stability	High	Predictive analytics for production efficiency, waste reduction algorithms
Urban Systems and Housing	Heatwaves, floods, air pollution, infrastructure overload	Very high – dense population and complex service interde-pendencies	High	Smart city platforms, AI-driven waste and water management, urban climate modeling
Finance and Insurance	Market instability, climate-related asset devaluation	Medium – indirect exposure through investment portfolios	Very high	AI-based climate risk assessment, automated underwriting, predictive loss modeling
Health and Social Services	Heat-related illnesses, epidemics, infrastructure damage	Medium – dependent on local preparedness and logistics	Moderate	AI health surveillance, epidemic prediction, resource allocation models

Source: constructed by [1; 4; 5; 8; 9; 10]

The comparative analysis reveals that infrastructure vulnerability remains highest in energy, transport, and urban systems, where physical assets are exposed to direct climate impacts. At the same time, AI adoption potential is strongest in agriculture, finance, and energy – sectors where predictive modeling and real-time analytics can significantly reduce risk and enhance efficiency. Integrating AI into infrastructure governance across all economic segments enables dynamic adaptation, reduces uncertainty, and supports the transition toward sustainable, data-driven climate resilience.

Conclusions. Infrastructure resilience and artificial intelligence represent interdependent pillars of climate adaptation across economic segments. Together, they create pathways toward sustainability, efficiency, and social well-being in an era of accelerating global climate risks. The conducted analysis confirms that climate change is no longer a sectoral or environmental issue alone – it has become a systemic challenge that affects all dimensions of economic activity and human security. The differentiated exposure of economic segments to climate threats demonstrates the necessity of adopting a multi-level, interdisciplinary approach that combines technological innovation, infrastructure modernization, and effective governance. Infrastructure resilience emerges as the central determinant of economic stability under climate stress. Energy grids, transport networks, urban systems, and agricultural supply chains are all facing growing risks from extreme weather, resource scarcity, and cumulative degradation. However, infrastructure is also a powerful platform for transformation: when intelligently designed and digitally connected, it becomes a mechanism of adaptation rather than vulnerability.

Artificial intelligence is rapidly evolving into a strategic instrument of climate governance. Its capacity to process massive data streams, model complex interactions, and support real-time decision-making enables policymakers and industries to anticipate threats, allocate resources efficiently, and reduce losses. AI-driven climate modeling, predictive maintenance, and smart city systems already demonstrate measurable benefits in emission reduction and disaster prevention. Yet, the technological potential of AI must be balanced by ethical oversight, data transparency, and inclusiveness to avoid reinforcing global asymmetries in knowledge and resources. In sum, the synergy between infrastructure resilience and artificial intelligence represents not only a response to climate threats but also a foundation for a new model of sustainable development – one that transforms crisis management into proactive adaptation and turns vulnerability into opportunity. By aligning technological intelligence with ecological awareness and social responsibility, societies can build a resilient future where economic growth and climate security reinforce each other rather than compete.

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