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Sustainable AI in environmental economics and management: Current trends and post-COVID perspective

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Introduction

Environmental economics and management in the modern market economy is largely determined by context. The COVID-19 pandemic has shifted priorities from environmental protection to social programs and measures to stimulate economic growth (Almars et al., 2022; Balakesava Reddy et al., 2022; Lim and Abdul Ghani, 2022; Liu et al., 2022; Soomro et al., 2022). The problem is that insufficient attention and lack of funding threaten an environmental crisis, which implies the high relevance of studying as well as finding ways to prevent the latter today (Chen et al., 2022; Congjuan et al., 2022; Popkova, 2022; Robinson et al., 2022; Wang et al., 2022).

The important role of artificial intelligence (AI) theory in studying its impact on the ecological economics of management is emphasized in the works of Bartmann (2022), Bolton et al. (2021), Ghermandi et al. (2022), Gooroochurn et al. (2022), Hernandez et al. (2022), Ligozat et al. (2022), Mao et al. (2022), Nost and Colven (2022), Tuia et al. (2021), and Zhang (2022).

The existing interpretation of sustainable AI defines it as smart technology for maintaining stable and balanced development of economic systems (Popkova et al., 2020; Sætra, 2021; Minkkinen et al., 2022; Osipov et al., 2022). Threats to healthcare have become more acute in the context of a pandemic; therefore, based on the existing interpretation, medicine has become the main area of application of sustainable AI (Astobiza et al., 2021; Bolton et al., 2021; Choi et al., 2021; Visvizi, 2022; Wilson and van der Velden, 2022). The advantage of the current interpretation is that it allows flexibly rebuilding a stable AI, applying it in the most demanded areas (Popkova et al., 2022a; Popkova et al., 2022b; Popkova and Sergi, 2022).

But a serious drawback of the existing interpretation is that it directs sustainable AI to combat only current threats, which does not prevent future threats. From the point of view of environmental protection, reliance on the existing interpretation causes high risks of an environmental crisis and does not allow us to unlock the potential of sustainable AI in overcoming it (Su et al., 2021; Aman et al., 2022; Yu et al., 2022; Zhou et al., 2022).

Consequently, the existing interpretation of sustainable AI does not correspond to the development priorities of environmental economics and management and needs to be revised.

The article attempts to solve the problem of environmental crisis management through the increasing use of artificial intelligence (AI) in environmental economics and management. The motivation of the article and its relevance lies in the fact that the article seeks to most fully and reliably determine the potential of AI to protect the environment. Eco-efficiency is an important and integral criterion for any modern innovation, which includes AI. The purpose of the article is related to the study of current trends and post-COVID prospects for the development of environmental economics and management based on sustainable AI. The article consistently solves the following three tasks:

→ To rethink the essence of sustainable AI from the perspective of environmental economics and management;
→ To identify current trends in environmental economics and management and determine the features of its development both before the pandemic and in the conditions of the COVID-19 pandemic;
→ To determine the advantages and identify the post-COVID perspective of using sustainable AI in environmental economics and management based on international experience.

The contribution of the article to the literature consists of rethinking AI from the standpoint of environmental economics and management and revealing the ecological nature of AI. The novelty and originality of the article consist of the authors' concept of sustainable AI, under which it is offered to understand the use of AI in the interests of environmental protection. Based on the new concept, the contribution of sustainable AI to environmental economics and management is clarified. The article also takes into account the unique experience of sustainable AI's contribution to environmental economics and management in the context of the COVID-19 pandemic.

Sustainable AI: Rethinking from the perspective of environmental economics and management

This article is based on the theory of environmental economics and management and the latest research which has been published by Astadi et al. (2022), Cui et al. (2022), Fontoura and Coelho (2022), He et al. (2022), Li et al. (2022), Rathore et al. (2022), Su (2022), and Yaoteng and Xin (2022).

The existing interpretation aims AI at combating crisis phenomena in economic systems; therefore, it is most appropriate to call it anti-crisis AI (Benaben et al., 2020; De Nicola et al., 2020; Wang et al., 2020; Prahl and Goh, 2021; Shakira Fathima and Dilshad Begum, 2021; Hernandez et al., 2022; Simeonovski et al., 2022; Wang, 2022). The concept of "sustainability," in turn, is rooted in environmental protection, to which most of the UN SDGs are devoted (Buonomano et al., 2022; Carayannis et al., 2022; Maheshwari et al., 2022; Úbeda et al., 2022). Therefore, from the standpoint of environmental economics and management, a new interpretation of sustainable AI as a "smart" environmental protection technology is proposed.

The advantage of the authors' interpretation is that, first, it clarified the classification of the directions of AI usage; in particular, it clearly identified the socio-economic (anti-crisis AI) and environmental (sustainable AI) directions. Second, the new interpretation considers the use of AI in environmental economics and management as a preventive measure to combat the environmental crisis, allowing preventing it from arising.

Current trends in environmental economics and management and features of its development both before the pandemic and in the conditions of the COVID-19 pandemic

The applied use of AI reflects the number of academic-corporate peer-reviewed AI publications. Figure 1 shows the current (over the past 10 years) trends in the development of environmental economics and management in the world's leading countries by the number of these publications in 2021. The sample was formed based on the works of Aqeel et al. (2022), Li et al. (2021), Moradi et al. (2021), and Rahmat et al. (2022).

The sample is sufficient to reflect the target (considered on the scale of the world economic system) population, as it covers both developed and developing countries from different parts of the world. America in the sample is represented by the United States and Canada (developed countries); Asia—China and India (developing countries); Japan and South Korea (developed countries); Europe—Great Britain, Germany, France, the Netherlands, Switzerland, Spain, and Italy (developed countries).

The methodology of the study is based on the application of the trend analysis method, which is used to study the ten-year trend in the environmental efficiency of the economy. The choice of methodology is based on the works of Farzadfar et al. (2022), Local Burden of Disease (2021), and Paulson et al. (2021).

Figure 1 shows wide variations in AI sustainability even among the leading countries in its development in 2021. The ten-year trend of the Environmental Performance Index is positive in most countries and is most pronounced in China (+8.4%) and Switzerland (+8.6%). In India, it is zero, and in Japan, it is negative (−0.5%). According to the calculations of the World Bank (2022), total natural resource rent has demonstrated

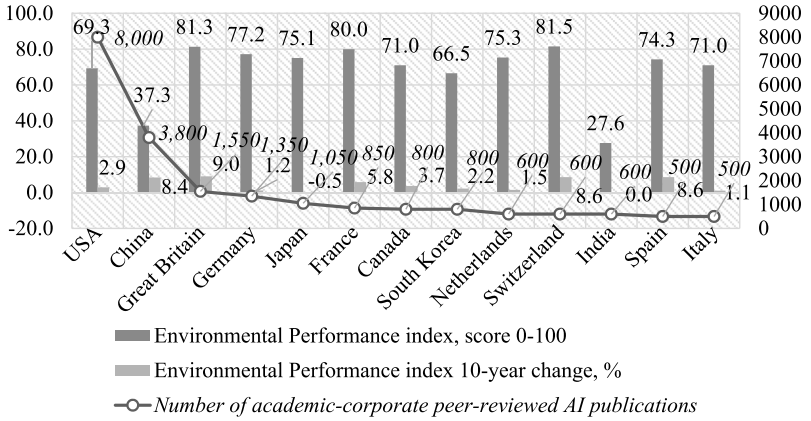

FIGURE 1
The Environmental Performance Index in 2020, its ten-year trend, and the number of educational and corporate peer-reviewed AI publications in 2021. Source: OECD AI Policy observatory (2022), Yale Center for Environmental Law and Policy, Center for International Earth Science Information Network, The McCall MacBain Foundation (2022).

great volatility over the past years. In 2009, it was 2.8%; in 2011, it increased to 4.9%; in 2016, it decreased to 1.5%; in 2019, it was 2%; and in 2020, it decreased to 1.9%. In this regard, the COVID-19 pandemic did not lead to an aggravation of the environmental crisis, but it also did not make a significant contribution to overcoming it, as it diverted attention from environmental economics and management.

Advantages and post-COVID perspective of using sustainable AI in environmental economics and management based on international experience

In 2020–2021, in the context of the COVID-19 pandemic, artificial intelligence was widely used in healthcare around the world. In China and Australia, AI has been used to diagnose COVID-19; in the United States, Apple has launched an application for "smart" screening of COVID-19; and in Germany, DOCYET has created a chatbot for remote "smart" support for consultations of COVID-19 patients (Roscongress, 2022). According to the Institute of Statistical Research and Knowledge Economics of the National Research University Higher School of Economics (HSE) (2022), AI has become the core of digital solutions of the COVID-19 era: in 2020, 17.9% of digital practical solutions in the OECD countries in COVIDTech were realized through the use of AI. In the context of the COVID-19 pandemic in 2020 in Russia, the demand for AI increased by 30.5%, and the supply increased by 23.9%.

New technological contours of the implementation of the federal project "Artificial Intelligence" of the national program "Digital Economy" have already been planned in Russia in the post-COVID perspective. Preparations are already underway to use sustainable AI for automatic ("smart") analysis of satellite images to identify violations of environmental legislation. In particular, control and monitoring of changes in the movement of objects in the environment will be carried out: identification in real-time of facts of illegal economic activity (development of the territory of specially protected natural areas, logging outside the provided cutting area, mining outside the boundaries of the approved mining allotment, etc.); identification of potentially fire-hazardous areas and fires; soil bonification; identification of categories and habitat classes according to Earth remote sensing data (Rospatent, 2022).

Based on the works of KPMG (2022), the following promising areas of application of sustainable AI and the advantages that it can provide for environmental economics and management in the post-COVID perspective (in the period up to 2030) are identified:

→ Development of green finance through the connection of the availability and cost of credit resources with the ESG initiatives of loan recipients using smart analytics (following the example of the German Landesbank Baden-Wuerttemberg);
→ Using sustainable AI for automated (more complete, transparent, efficient, and mass) standardized disclosure of financial information on combating climate change based on the experience of France (based on CDP, CDSP, IIRC, GRI, and SASB standards), as well as on the experience of Russia (Moscow Exchange: TCFD-reporting for the utility sector);
→ Automated (fair, efficient, and open) allocation of emission quotas (production and consumption waste) according to the experience of the European Union;
→ Smart environmental monitoring and automated calculation of ESG indices, as well as the compilation of sustainable development ratings.

The proposed directions are not exhaustive, but they demonstrate the great contribution that sustainable AI can and should make to environmental economics and management from the post-COVID perspective.

Discussion

The article contributes to the development of the concept of environmental economics and management by substantiating the new role that AI should play in its framework. Unlike Astobiza et al. (2021), Bolton et al. (2021), Choi et al. (2021), Minkkinen et al. (2022), Osipov et al. (2022), Popkova et al. (2020), Sætra (2021), Visvizi (2022), and Wilson and van der Velden (2022), it has been proved that the existing interpretation of sustainable AI does not allow to unlock the potential of AI to fight new global challenges and therefore needs to be revised. Distinctive features of the proposed new authors' interpretation are:

→ The transition from the practice of flexible redirection of AI from one industry to another (for example, in healthcare, in the context of the COVID-19 pandemic) to a fixed, stable, and long-term application of sustainable AI in environmental economics and management;
→ Sustainable AI should be given a new role related to preventive environmental crisis management (as opposed to dealing with current threats, which is a characteristic of the existing interpretation).

The authors' interpretation of sustainable AI clearly defined the boundaries of the ecological direction (in environmental economics and management) and separated it from the anti-crisis direction, and thereby, it clarified the classification of the directions of AI usage. The new interpretation made it possible to classify the types of AI more precisely, as it identified anti-crisis AI and sustainable AI.

The contribution of this study is that it allowed us to reconsider the experience of the pandemic from the standpoint of environmental economics and management. Environmental implications of COVID-19 in contrast to Aqeel et al. (2021), Ge et al. (2022), and NeJhaddadgar et al. (2020) turned out to be neutral. The value of the obtained results for academic purposes lies in the fact that they showed that even in the context of a pandemic and lockdown, humanity continued to inflict damage on the environment and did not advance in decarbonization issues.

In this regard, radical measures are needed, among which an important place is occupied by the development of sustainable AI recommended in the article in environmental economics and management. The post-COVID perspective of combating climate change and developing sustainable communities and territories is associated with the full-scale implementation of AI and its active use for sustainable development.

Conclusion

Thus, the article revealed the current trends in the development of environmental economics and management related to the increase in environmental performance and the reduction of total natural resource rents and also pointed to the insignificant role of sustainable AI in achieving these results. The main conclusion obtained in the article is related to the fact that sustainable AI has a significant potential for the development of environmental economics and management, but this potential has not yet been discovered. Also, the post-COVID perspective of environmental economics and management is associated with a fuller disclosure of the potential of sustainable AI.

The main results of the study are as follows: first, sustainable AI is rethought from the standpoint of environmental economics and management, and its new interpretation is proposed as smart technology for protecting the environment.

Second, modern trends in environmental economics and management have been identified: 1) a positive ten-year trend in the Environmental Performance Index and 2) high volatility of total natural resource rents. Because of this, in contrast to Chen et al. (2022), Congjuan et al. (2022), Popkova (2022), Robinson et al. (2022), and Wang et al. (2022), substantiated that the COVID-19 pandemic did not have a critical impact on the environment due to ecological AI economics and management.

Third, based on the international experience of the OECD countries and Russia, the advantages and post-COVID prospects of using sustainable AI in environmental economics and management are substantiated: 1) development of ESG initiatives of loan recipients using smart analytics; 2) disclosure of financial information on combating climate change; 3) automated allocation of carbon credits; and 4) smart environmental monitoring and automated calculation of ESG indices.

The theoretical significance of the article is that it offers the authors' interpretation of sustainable AI, which allows for increasing its role and importance in environmental economics and management. The practical significance of the results of the study is that the authors' recommendations allow us to fully reveal the potential of sustainable AI in the field of environmental crisis management from the post-COVID perspective. Policy implications lie in the usefulness of expanding the use of AI in the interests of protecting the environment in such areas as AI-green finance, smart climate reporting, intelligent support for the allocation of emission quotas, as well as smart environmental monitoring.

Restrictions

Although the article reveals the successful international experience of using sustainable AI in the practice of environmental economics and management, the proposed

recommendations are general in nature and require more detailed analysis before applying them practically. In future scientific research, it is advisable to provide an in-depth study of each proposed promising direction of using sustainable AI separately in environmental economics and management.

The limitation of the current study is also the isolated consideration of AI for the most in-depth study of its environmental nature in support of sustainable development of the economy and management. A promising direction for future research is a comprehensive study of the experience and prospects for using advanced digital technologies—not only AI but also the Internet of Things (IoT), robots, etc.—in environmental economics and management to achieve a "synergy effect" in the form of accelerating the pace of sustainable development.

Author contributions

SL and AB contributed to the conception and design of the study. AA organized the database. SL wrote the first draft of the manuscript. AB and AA wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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