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RESEARCH ARTICLE

## Conceptualizing the global environmental challenges of our time: Technological and sociocultural aspects

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### Abstract

**Objectives.** Nowadays, the global environmental agenda has become a significant factor in world politics and international relations. Along with climate change, growing demographic and technological pressures on the environment, the degradation of ecosystems, and the depletion of nonrenewable natural resources represent a single set of environmental challenges for humanity as a whole, which will remain relevant throughout the 21st century. The objective of this article is to consider the technological and sociocultural aspects of modern global environmental challenges in terms of their interconnectedness.

**Methods.** The article is based on the systems history method and the cycles and waves approach to studying global dynamics.

**Results.** Considering the main features of humanity’s interaction with the environment, the factors and nature of changes in the anthropogenic burden are analyzed to reveal the stages according to which environmentalism is shaped as part of the global political agenda. Based on a comparison of the climatic picture of the past and modernity, priorities for steering the environmental agenda as a key component of the emerging world system are identified.

**Conclusions.** The overall anthropogenic impact on the environment is determined by a number of sociocultural, economic and technological factors. Although the degree of this impact has been increasing throughout history, climate change as such does not have a pronounced anthropogenic nature, being driven mainly by solar and geophysical cycles. Meanwhile, the very fact that climate change has become a key element of the global environmental agenda often leads to imposing regulatory requirements and technological standards that slow down the pace of industrialization and modernization in developing countries. In the context of the emerging world system architecture, it becomes possible to rethink the environmental agenda and repurpose it to take account of the priorities of climate forecasting and adaptation to ensure environmental safety while developing environmentally appropriate nature-similar technologies.

**Keywords:** global environmental challenges, environmental agenda, anthropogenic pressures, technosphere, spectrums of needs, nature-similar technologies, national security, the World Majority

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## НАУЧНАЯ СТАТЬЯ

# Осмысление глобальных экологических вызовов современности: технологические и социокультурные аспекты

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### Резюме

**Цели.** В настоящее время глобальная экологическая повестка стала значимым фактором мировой политики и международных отношений. Происходящие в мире климатические изменения, нарастающее демографическое и техногенное давление на среду обитания, деградация биогеоценозов и истощение невозобновляемых природных ресурсов представляют собой единый комплекс экологических вызовов для всего человечества, который останется актуальным в течение всего XXI века. Целью настоящей статьи является рассмотрение технологических и социокультурных аспектов глобальных экологических вызовов современности в их взаимосвязи.

**Методы.** В статье используются системно-исторический метод и циклически-волновой подход к изучению мировой динамики.

**Результаты.** Рассмотрены особенности взаимодействия человечества с природной средой, проанализированы факторы и характер изменения антропогенных нагрузок в исторической ретроспективе, показаны этапы становления глобально-политической повестки экологизма, проведено сравнение климатической картины прошлого и наших дней, обозначены приоритеты управления экологической повесткой в новом мироустройстве.

**Выводы.** Обще антропогенное влияние на природную среду определяется рядом социокультурных, экономических и технологических факторов. Хотя степень этого влияния на протяжении истории повышается, однако именно климатические изменения не имеют выраженной антропогенной природы, будучи подчинены главным образом солнечным и геофизическим циклам. Наряду с этим, тема климатических изменений стала одним из ключевых элементов глобальной экологической повестки, которая в ряде случаев приводит к постановке регуляторных требований и технологических стандартов, затрудняющих темпы индустриализации и модернизации в развивающихся странах. В условиях формирования новой системы международных отношений появляется возможность переосмысления экологической повестки с дальнейшим перенаправлением ее на приоритеты климатического прогнозирования и адаптации, обеспечения экологической безопасности и развития природоподобных технологий.

**Ключевые слова:** глобальные экологические вызовы, экологическая повестка, антропогенные нагрузки, техносфера, спектры потребностей, природоподобные технологии, национальная безопасность, Мировое большинство

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## INTRODUCTION

Currently, the global environmental agenda has become a significant factor in world politics and international relations. Global climate change, growing demographic and technogenic pressures on the environment, degradation of biogeocenoses, and depletion of nonrenewable natural resources represent a single set of environmental challenges for humanity as a whole, which will remain relevant throughout the 21st century. Meanwhile, the frequent use of the environmental agenda as a tool of international regulation reveals contradictions between different groups of countries in terms of their levels of technological development and long-term economic growth priorities. In light of the latter circumstance, it becomes important to identify the causes of the global biosphere-ecological crisis observed today, for which it is necessary to refer to objective biosphere-wide, species-specific, and sociocultural patterns in light of some relevant aspects of the global historical process.

### THE SAPIENS PHENOMENON: FEATURES OF INTERACTION WITH THE NATURAL ENVIRONMENT

*Homo sapiens* is the only biological species in the Earth's biosphere that engages in the conscious, purposeful transformation of the natural environment to obtain various intermediate resources, material products, and other goods that did not previously exist in its habitat [1, 2].

However, like other biological species, humans also have their own initial, predetermined ecological niche, whose depletion poses a risk to the further existence of the species. Nevertheless, as culture (including the technosphere), material practices, and energy capabilities have developed, the ecological niche of *Homo sapiens* has constantly expanded [3]. At the same time, there is always a certain set of parameters for humanity's natural habitat, the significant violation of whose boundary values results in even the most extensive habitats becoming unsuitable for the further reproduction, survival, and development of the species.

Along with that, the human population has another important difference from the rest of the Earth's biosphere: while all other biological species have a deterministic spectrum of needs that remains unchanged over long periods of time, the spectrum of human needs is inherently variable, hierarchically complex, and throughout history has tended to expand as culture develops in terms of self-knowledge, self-organization, and material practice [3, 4].

### ANTHROPOGENIC IMPACTS IN HISTORICAL RETROSPECTIVE

In the most general terms, four interrelated factors can be identified that determine the level of anthropogenic pressure on the natural environment: demographics, spectrum of needs, energy base, and level of development of productive forces (including technological development). Throughout human history, the dynamics of these factors have been uneven and nonlinear; moreover, their abrupt changes have always led to the transition of civilization to a qualitatively new state, characterized by the concept of "phase of development" [5].

The first such phase transition (from the archaic to the traditional phase of development) known as the Neolithic Revolution is associated with the emergence of a productive economy. At that time, the development of crop rotation, early construction technologies, and metallurgy led to a multiple increase in the human population and the first surge in anthropogenic pressure on the Earth's ecosystem. However, since human energy consumption was still incomparably lower than the energy capacity of natural global processes at the initial stage of civilization's development, the increased ecological footprint of humanity occurring at that time remained negligible [5, 6].

With the transition from the traditional to the industrial phase of development during the 18th century, humanity began to use technogenic energy for the first time, which then increasingly replaced biogenic energy in all production cycles, exponentially increasing the energy intensity of the *Homo sapiens* species.

The growth of anthropogenic pressure during the first industrial revolution was also associated with a new combination of sociocultural factors that included the secular ideology of bourgeois liberalism and the capitalist mode of production. This combination led to a significant expansion of the mass spectrum of needs, an increase in production volumes, and a corresponding reduction in production cycles, which for the first time in history began to have a noticeable impact on the natural environment [7, 8].

By the beginning of the first scientific and technological revolution at the turn of the 19th and 20th centuries, the world's population had reached 1 billion, while the aforementioned sociocultural factors continued to exert their influence and even intensified. Under the new technological conditions, this manifested itself in the beginning of the era of conveyor-belt production of mass-market goods.

A separate important phenomenon of that time was the emergence of the mass communications industry, which, as it developed, became a significant factor in the artificial expansion of the spectrum of degradative needs. This last point requires clarification: unlike basic, demographically determined personal, family, and infrastructural needs, degradative needs are artificially cultivated needs, whose satisfaction objectively harms the consumer, society, and the environment [4, 9].

Throughout the 20th century and up to the present day, under the influence of sociocultural factors in the world as a whole, especially in developed countries, there has been a predominance of such artificially created needs. This, combined with a manifold increase in population to 8 billion people and accelerating technological change, has resulted in a historically unprecedented increase in anthropogenic pressures on the environment [10].

### **ECOLOGISM: THE EMERGENCE OF A GLOBAL POLITICAL AGENDA**

During the second half of the 20th century, the West began to show genuine concern for preserving the ecological niche necessary for humanity, while at the same time viewing environmental challenges as an incentive to consolidate efforts and strengthen its own technological and institutional advantages [11]. Based on this motivation and relying on their collective intellectual, technological, and (most importantly) institutional leadership, Western countries began to systematically form a new global political agenda centered on environmental issues and, in particular, climate change.

The milestones of this agenda are the report to the Club of Rome entitled "The Limits to Growth" (Meadows spouses report, 1972), the report of the United Nations

World Commission on Environment and Development published under the heading of "Our Common Future" (the Brundtland Report, 1987), the adoption of Agenda 21 and the United Nations Framework Convention on Climate Change at the Rio de Janeiro conference (1992), the signing of the Kyoto Protocol (1997), the adoption of the Millennium Declaration at the United Nations General Assembly meeting in New York (2000), the adoption of the 2030 Agenda and the United Nations Sustainable Development Goals, the signing of the Paris Agreement (2015), the latest COP<sup>1</sup> conferences in Glasgow, Sharm El Sheikh, and Dubai (2021–2023), and the United Nations Summit of the Future held in September 2024 [12].

All of the above policy documents and measures within this agenda are united by the fundamental idea that climate change is predominantly anthropogenic in nature, is primarily linked to the greenhouse effect (global warming), and will have catastrophic consequences for humanity if left unchecked.

The climate agenda, which has been institutionalized and actively implemented in international political practice, has acquired the quality of a modern quasi-ideology that can be defined as political environmentalism. In its radical version, this quasi-ideology is already taking on radical features, including placing *Homo sapiens* on a par with the animal world and even with the plant kingdom, thus diminishing the value of human life and all cultural achievements.

Public debates on climate policy sometimes reveal selective use of scientific data, reflecting the diversity of positions and interests in this area. Another sign of the purely political and instrumental nature of this quasi-ideology is the unevenness of its media coverage: in some years, there is massive media promotion of relevant ideas, events, and personalities, while in others, the climate agenda virtually "fades away" due to the fact that global politics is being pursued by other means during that period.

A telling example of the politicization of environmental discourse is the work of Swedish eco-activist Greta Thunberg, whose public appearances have been interpreted as a tool for creating emotional pressure to promote the climate agenda. It is noteworthy that her entire family has consciously switched to veganism, viewing it as a personal contribution to reducing their carbon footprint. In this way, environmental issues are taking on the characteristics

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<sup>1</sup> Discussion on the environmental agenda and the outcomes of the COP28 climate conference in Dubai. Valdai Discussion Club. <https://ru.valdaiclub.com/multimedia/video/diskussiya-pokologicheskoy-povestke-i-itogam-cop28/>. Accessed September 06, 2025. (In Russ.).

of mass ideological mobilization, in which individual practices and values are transformed into elements of global influence.

At the same time, it is important to understand that the environmental agenda is increasingly intertwined with issues of economic, energy, and technological policy [11]. From a non-western perspective, especially the countries of the Global South, it may often seem that the strategic goals of this policy are to increase global socioeconomic inequality and exacerbate disparities in terms of access to technologies and resources necessary for the development modernization.<sup>2</sup> At the same time, international environmental policy practice shows a tendency for industrialized countries to maintain their technological leadership and priority access to financial and innovative resources in the process of energy transition [13].

### MULTIFACTORIAL NATURE OF CLIMATE CHANGE: FROM THE PAST TO THE PRESENT

Given that the current global environmental agenda focuses particularly on anthropogenic factors of climate change, it is important to note that there are other scientific approaches that view climate dynamics as the result of complex interactions between natural and anthropogenic processes. In this context, it is appropriate to briefly consider the nature and factors of climate change, based on both paleoclimatological data and the results of contemporary research in the field of climate science [14].

In general, the planet's climate dynamics represent a system of interconnected cyclical processes of varying duration. The main factors determining the formation of the Earth's climate are: (1) the power of absorbed solar radiation; (2) the power of the Earth's own radiation from its interior; and (3) the spatial relationship between the world's oceans and the geostuctures of the land.

Thus, geological timespans measured in millions of years can be characterized by the alternation of cryoeras and thermoeras, as determined by the possibility of continuous heat and mass transfer in the equatorial plane of the planet. Accordingly, since in our geological era the equator is "covered" by two continents, humanity as a whole has invariably lived and continues to live in a climatic cryoera. During thermoeras, however, the Earth's temperature was much higher.

Furthermore, over tens of thousands of years, glacial and interglacial periods regularly alternate, including the alternation of over centuries of minor ice ages and so-called climatic optimums. Thus, the fall of the Roman Empire and the crisis of the ancient world partially coincided with a phase of climatic cooling known as the Late Antique Little Ice Age. In turn, the relative warming in the 11th–12th centuries, known as the Medieval Climate Optimum, was accompanied by favorable climatic conditions in the North Atlantic, which, in particular, allowed the Norse civilization to colonize the southern coastal areas of Greenland, which is now covered by a glacier.

Five hundred years later, at the turn of the 17th century, another minor ice age brought ice to the Moskva River in summer and the well-known years of poor harvests that caused famine in medieval Tsarist Russia. It is important to note here that the overall temperature difference between the climatic situations of the 12th and 17th centuries was from 1.5 to 2°C, i.e., a range that is actively discussed in international climate agreements and serves as a benchmark for assessing the possible consequences of global warming.<sup>3</sup> At the same time, it is obvious that the described differences between the climatic situation of the 12th and 17th centuries could not have been related to human activity, given the vanishingly small energy intensity and anthropogenic footprint of global civilization in that pre-industrial era.

Today, we are witnessing another phase of climate fluctuations caused by natural geophysical and astronomical cycles, along with anthropogenic factors [14].

Finally, according to a number of Russian and foreign studies, the natural factors influencing modern climate warming include a change in the angle of the Earth's axis of rotation, which affects the insolation of polar and equatorial regions and, as a result, the intensity of meridional heat and mass transfer [15–17]. At the same time, most climate models point to the significant role of anthropogenic factors—primarily the increase in greenhouse gas concentrations—in shaping current climate trends, which remains the subject of active scientific debate.

Moreover, various hypotheses explaining the processes of atmospheric ozone destruction are discussed in scientific literature. Along with anthropogenic sources, in particular chlorofluorocarbon emissions, which played a key role in the formation of ozone "holes" at the end of the 20th century, natural geophysical factors are also

<sup>2</sup> Barabanov O., Bepalov A., Ibragimova K., Koltashov V., Poletaev D., Savorskaya E. *The social dimension of the "global commons": can inequality in the world be overcome?* Valdai Discussion Club. <https://ru.valdaiclub.com/a/reports/sotsialnoe-izmerenie-globalnogo-dostoyaniya/>. Accessed September 05, 2025. (In Russ.).

<sup>3</sup> Special report: global warming of 1.5°C. IPCC. <https://www.ipcc.ch/sr15/>. Accessed September 10, 2025.

being studied, including degassing processes from the Earth's interior, volcanic activity, and solar variability. Studying the relationships between these processes opens up opportunities for more accurate forecasting of meteorological changes and assessment of climate risks [18].

Thus, past and present climate change is mainly caused by natural factors. Anthropogenic impact only serves to amplify the overall climate process [19]. However, unlike previous generations, humanity now has sufficient scientific and technological capabilities not only to predict adverse climate change, but also to adapt its environment to these changes in advance using the state-of-the-art technologies and governance principles [10, 12, 14].

### **STEERING THE ENVIRONMENTAL AGENDA IN THE NEW WORLD SYSTEM ARCHITECTURE: THE ROLES OF SCIENCE AND MULTILATERAL DIPLOMACY**

Apart from objective macro-processes beyond human control, genuine environmental challenges arising at the present time are caused by the cumulative anthropogenic impact on the natural environment, which is primarily determined by technological and sociocultural factors. Therefore, given that the main sociocultural factor is the artificially formed spectrum of needs already described, the technological factor should be considered in more detail.

Throughout human history, the technosphere has developed as a means of protection from the natural environment and, in many ways, as a counterbalance to it. The logical consequence of this approach has been the primitive principles of operation of the technologies available to us, which are inadequate in terms of the complexity and sustainability of the natural processes observed.

The majority of global energy sector is still based on burning fossil fuels. Even modern nuclear power plants are based on traditional principles of thermal power engineering, where the key process remains the conversion of thermal energy into mechanical and electrical energy through the formation of steam. However, nature itself demonstrates the prevalence of biochemical and thermonuclear fusion reactions characterized by energy release.

In this connection, a promising direction involves the development of nature-similar technologies<sup>4</sup> developed

<sup>4</sup> Decree of the President of the Russian Federation No. 818 dated November 2, 2023, "On the Development of Nature-Inspired Technologies in the Russian Federation." Official publication of legal acts. <http://publication.pravo.gov.ru/document/0001202311020021>. Accessed September 25, 2025. (In Russ.).

by the Kurchatov Institute<sup>5</sup> in Russia, which now has a branch in Belarus.

These are technologies that model the principles of ecological systems to reproduce natural processes in the form of technical solutions.<sup>6</sup> Nature-similar technologies are based on the use of renewable resources, i.e., they do not disrupt the cycles of substances in nature, and are also highly energy efficient.<sup>7</sup>

The interconnection between technological and environmental aspects of global dynamics is particularly important from the perspective of ensuring the comprehensive security of sovereign states. Thus, according to the current version of the National Security Strategy of the Russian Federation, a number of strategic national priorities are linked to scientific and technological development, environmental security, and rational use of natural resources. In addition, taking into account long-term trends in Russia and worldwide, the national interests of the Russian Federation include environmental protection, conservation of natural resources, adaptation to climate change, and ensuring the sustainable development of the Russian economy on a new technological basis.<sup>8</sup>

At the same time, the Climate Doctrine of the Russian Federation rightly notes that problems related to climate change, in particular, ensuring a balance between economic efficiency and social justice, eliminating potential conflicts of interest in connection with extreme manifestations of climate change (heat waves, floods, droughts, and other phenomena) cannot be solved by scientific methods alone. Under such conditions, the necessary balance can only be achieved through comprehensive management decisions.<sup>9</sup> When developing these decisions, it is advisable to take

<sup>5</sup> Thematic session "Nature-like technologies: a new era of human development" as part of the Third Congress of Young Scientists. Roscongress Foundation. <https://roscongress.org/sessions/kmu-2023-prirodopodobnye-tekhnologii-novaya-era-razvitiya-chelovechestva/about/#>. Accessed September 22, 2025. (In Russ.).

<sup>6</sup> Decree of the President of the Russian Federation No. 145 dated February 28, 2024, "On the Strategy for Scientific and Technological Development of the Russian Federation." Government of Russia. <http://government.ru/docs/all/152305/>. Accessed September 30, 2025. (In Russ.).

<sup>7</sup> Nature-like technologies. Kurchatov Institute Research Center. <https://nrcki.ru/catalog/nauka/fundamentalnye-i-prikladnye-nauchnye-issledovaniya/nbiks-prirodopodobnye-tekhnologii/>. Accessed October 02, 2025. (In Russ.).

<sup>8</sup> Decree of the President of the Russian Federation No. 400 dated July 2, 2021, "On the National Security Strategy of the Russian Federation." President of Russia. <http://www.kremlin.ru/acts/bank/47046/page/1>. Accessed October 02, 2025. (In Russ.).

<sup>9</sup> Decree of the President of the Russian Federation No. 812, dated October 26, 2023, "On the Approval of the Climate Doctrine of the Russian Federation." Official publication of legal acts. <http://publication.pravo.gov.ru/document/0001202310260009>. Accessed October 04, 2025. (In Russ.).

into account the fact that the vector of development of the global economy—and, accordingly, scientific research—is currently shifting from robotization and automation (Industry 4.0) to the development of sociocentric and environmentally sustainable technologies [20].

## CONCLUSIONS

Thus, when speaking about global environmental challenges in general, the understanding of this topic outlined above opens up opportunities for interested and responsible actors in global politics to form and promote common positions in this area within the framework of new formats for interaction between the countries of the World Majority and specialized organizations of the United Nations system that are oriented toward a more balanced approach to global development that takes into account the interests of all groups of countries. Such common positions may primarily concern the following issues:

- adaptation to expected climate change, climate forecasting tools, and forward-looking energy policy;
- principles of prudent management of scientific and technological progress, priority of developing nature-like technologies;
- the need to change the paradigm of economic and cultural development in order to minimize the range of degrading needs;
- principles of responsible production, fair distribution, and moderate consumption in the global economy.

In such a context, the updated “environmental agenda of the World Majority” could become a real unifying direction for cooperation within international organizations, transcending any ethnic and religious differences.

### Authors' contributions

**N. Yu. Ryabtchenko**—conceptualization, methodology, writing (original draft preparation).

**A. P. Fedorov**—literature review, manuscript editing, revising the research content.

All authors have read and agreed to the published version of the manuscript.

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