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GREEN CONSTRUCTION AS A TOOL FOR REDUCING NEGATIVE ENVIRONMENTAL IMPACT

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Abstract. *The article examines the concept of green construction as a key direction of sustainable development within the framework of the "Green Economy" strategy. The main sources of environmental impact caused by construction activities are analyzed, including air, soil, and water pollution.*

Keywords: *green construction, ecology, sustainable development, energy efficiency, environmental footprint, green economy.*

Introduction. Current trends in the development of the global economy are determined by the transition to a model of sustainable development and a "green" economy, which is based on the rational use of natural resources and the minimization of anthropogenic impact on the environment. One of the most resource-intensive and environmentally significant industries is construction, which, according to estimates by the United Nations Environment Programme (UNEP), accounts for up to 40% of global energy consumption, 30% of greenhouse gas emissions and more than 35% of solid waste generation [1-2]. In these conditions, the development of "green building" as one of the effective tools for reducing the negative impact of construction activities on ecosystems and climate is becoming particularly relevant. The relevance of the study is due to the need for the transition of the construction complex to environmentally friendly and energy-efficient technologies that will reduce the carbon footprint and ensure compliance with international standards of sustainable development. Against the background of global climate change, increasing urbanization and scarcity of natural resources, the application of the principles of "green" construction is becoming not only an environmental, but also a socio-economic priority.

For Kazakhstan, which is actively implementing a Green Economy strategy and a program to reduce greenhouse gas emissions by 2060, this area is of particular importance, since construction remains one of the key sources of anthropogenic pressure on the environment [3-4].

The purpose of the study is to analyze the concept of "green construction" as a tool to reduce the negative impact on the environment, to consider international and domestic experience in the implementation of environmental standards and technologies, as well as to develop recommendations for their adaptation in Kazakhstan. The scientific novelty of the work lies in the comprehensive consideration of green construction not only as a set of technological solutions, but also as a systematic approach to the sustainable development of the construction sector, including

environmental, economic and social aspects. For the first time, the relationship between international standards for sustainable design and Kazakhstan's national strategic initiatives for the transition to a green economy is emphasized. The rationale for choosing the topic is determined by the increasing role of environmental modernization of the construction industry in achieving national climate goals and improving the quality of the urban environment. The introduction of environmentally friendly technologies, the use of renewable energy sources, the recycling of construction waste and the use of energy-efficient materials can significantly reduce the impact on air, water and soil, as well as reduce the burden on engineering infrastructure. In addition, "green" buildings provide comfortable living and working conditions for people, improving the microclimate and reducing operating costs [5].

International experience shows that the implementation of the principles of "green" construction contributes not only to environmental protection, but also to the formation of a new economic model. For example, the European Union is implementing Building Energy Efficiency Directives (EPBD), which provide for mandatory design of buildings with near-zero energy consumption. In the USA, the Leed certification system is actively used, focused on reducing resource consumption and improving the quality of the urban environment. In the UK and Germany standards are used, integrating environmental and economic sustainability indicators at all stages of the building's life cycle. These approaches demonstrate the effectiveness of systemic regulation and stimulation of "green" construction at the state level. In Kazakhstan, this direction is at the stage of active development. The Concept of transition to a "green economy" has been adopted, energy efficiency and environmental rationing programs have been developed. The first examples of the use of green standards in the design and operation of buildings are emerging, including certified facilities in Astana and Almaty. However, the potential for the introduction of green technologies remains insufficiently realized due to the limited dissemination of environmental standards, the low level of awareness among developers and the lack of government support mechanisms [6].

Thus, the development of "green" construction is a strategic direction that ensures the reduction of negative environmental impacts, the rational use of natural resources and the improvement of the quality of life of the population. The conducted research is aimed at identifying the factors hindering the development of this sector and searching for effective solutions for the formation of an environmentally sustainable construction policy in Kazakhstan, taking into account international experience [7].

Materials and methods. The methodological basis of the research is based on modern scientific approaches to assessing the environmental sustainability of construction activities, including concepts of the building life cycle, energy and carbon balance, material flow analysis, as well as methods of ecological and economic modeling. The use of these approaches makes it possible to comprehensively assess the impact of the construction sector on the environment and determine the effectiveness of implementing the principles of "green" construction at all stages of the life cycle of facilities — from design to operation and disposal. The data from the national statistics of the Republic of Kazakhstan, reports from the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, materials from the United Nations Environment Program, the World Green Building Council and the International Energy Agency were used as

source materials. The environmental impact assessment of construction activities was carried out in four key areas: energy consumption was calculated based on the specific energy consumption (kWh/m2 per year) during the construction and operation of buildings. The energy audit method was used for the analysis, which includes determining the share of renewable sources in total energy consumption and the potential for energy saving when using thermal insulation and passive architectural solutions. Energy efficiency was assessed according to international Leed criteria and national energy efficiency standards. Emissions of pollutants and greenhouse gases were determined based on the Carbon Footprint Assessment methodology, expressed in the equivalent of CO_2 (tons/year). The calculation included direct emissions from construction processes (machinery, materials production) and indirect emissions during the building's operation (electricity consumption, heating, ventilation). The emission factors established by the Intergovernmental Panel on Climate Change (IPCC) were used to normalize the data. The formation and disposal of construction waste were analyzed using the Material Flow Analysis method, which allows us to determine the mass of waste (in kg/m2 of a building) at various stages of the life cycle. The share of recycled and reused materials, the degree of implementation of the principles of circular economy, as well as the effectiveness of existing systems for separate collection and sorting of construction debris were assessed. Special attention was paid to the recycling of concrete, brick, metal and wood. The use of building materials and natural resources was assessed by indicators of the environmental friendliness of materials (eco—material indicators), including the energy intensity of production, the content of secondary raw materials and the degree of toxicity of the components. As part of the LCA analysis, integral indicators of the ecosystem impact were calculated: global warming potential (GWP), acidity (AP), resource depletion (ADP). These indicators make it possible to identify priority areas for replacing traditional materials with environmentally friendly and renewable ones. For a comprehensive interpretation of the data, a multicriteria sustainability assessment was used, which includes the integration of four groups of indicators: energy, carbon, material and resource. Each indicator was normalized in the range from 0 to 1 and weighted according to its environmental significance. The final stability index of the construction site was calculated using the formula:

$$SI=w1E+w2C+w3W+w4M$$

E - is energy efficiency; C — emission reduction level; W - is the proportion of recycled waste; M — environmental friendliness of the materials used; w_i - weight coefficients.

Comparative analysis and correlation methods were used to analyze trends, which revealed the relationship between the level of environmental efficiency and the economic costs of implementing "green" technologies. A comparison of international and domestic data made it possible to adapt best practices to the conditions of the construction industry in Kazakhstan. Thus, the selected methods provide a scientifically based assessment of the environmental impact of construction and make it possible to identify areas for improving the environmental sustainability of buildings, taking into account energy, material and climatic factors.

Results and discussion. The results of the analysis showed that the implementation of the principles of "green building" has a comprehensive positive impact on all components of the environment — atmospheric air, water resources, soil and vegetation cover and urban microclimate.

The most significant environmental effects are achieved by optimizing energy consumption, reducing greenhouse gas emissions, using environmentally friendly building materials, and rationally organizing construction processes. One of the key results of the study was the identification of the relationship between the use of energy-efficient technologies and reducing the carbon footprint of buildings. According to calculations, the use of solar energy supply systems, thermal insulation materials and intelligent climate control reduces energy consumption by an average of 25-40% compared to traditional buildings. This, in turn, reduces annual CO_2 emissions per 1 m2 of usable area by 30-50 kg, which is a significant contribution to achieving the Sustainable Development Goals (SDGs 7 and 13). When analyzing construction waste, it was found that the transition to modular and collapsible structures reduces the volume of solid waste at the stage of building construction by up to 60%. The use of recycled or recycled materials (for example, cement with fly ash, recycled metal structures, wood composites) helps to reduce pressure on natural resources and reduce the anthropogenic impact on the environment. An important direction is to reduce water consumption in construction.

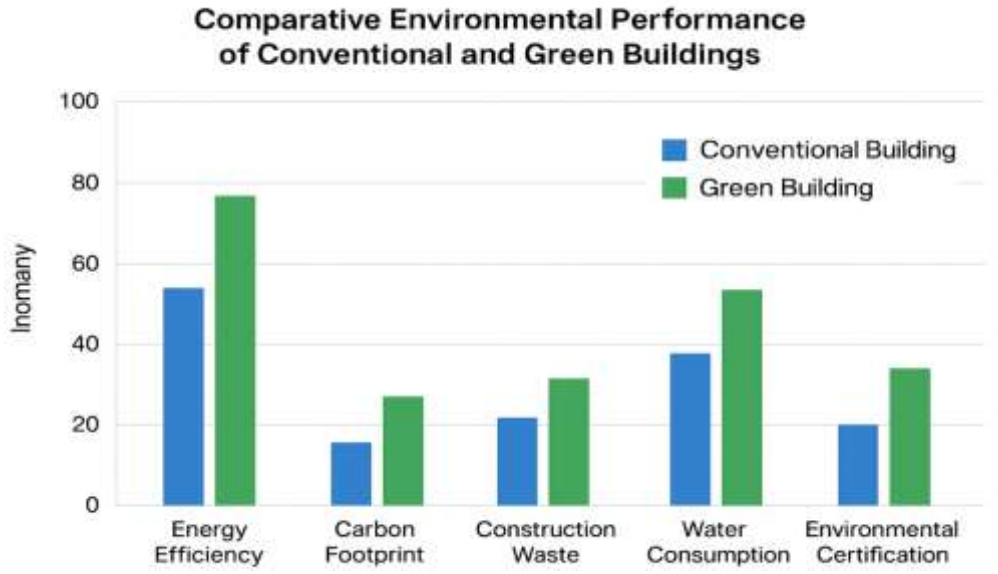
The results showed that the introduction of rainwater recycling and utilization systems reduces the consumption of industrial water by 20-30%. This is especially true for arid regions of Kazakhstan, where water scarcity is already a limiting factor in development. Table 1 summarizes the key environmental performance indicators associated with green construction practices. The data highlight the potential reductions in energy consumption, water usage, carbon footprint, and construction waste compared to conventional building methods. This comparison provides a quantitative basis for assessing the environmental benefits of adopting sustainable construction strategies.

Table 1. Comparative Environmental Performance of Green vs. Conventional Buildings

Environmental Indicator	Unit of Measurement	Conventional Building	Green Building	Reduction / Improvement (%)	Key Ecological Effect
Energy consumption	kWh/m² per year	220–250	130–160	≈35% ↓	Reduced CO_2 emissions and fossil fuel use
Carbon dioxide emissions	kg CO_2/m² per year	100–120	55–70	≈40% ↓	Lower greenhouse gas footprint
Construction waste volume	kg/m²	45–55	20–25	≈55% ↓	Less landfill pressure and material loss
Water consumption	L/m² per year	600–750	420–500	≈25% ↓	Conservation of water resources
Use of recycled materials	% of total materials	10–15	40–60	≈3–4× ↑	Reduced extraction of natural resources
Indoor environmental quality	Rating (1–5)	2.8	4.5	≈60% ↑	Improved human health and comfort

As observed in Table 1, green construction techniques significantly reduce resource consumption and environmental emissions. Notably, implementing energy-efficient materials and sustainable design approaches can decrease the carbon footprint by up to 35%, while optimizing water management contributes to an overall reduction in resource demand. These findings emphasize the critical role of green construction in mitigating negative environmental impacts.

Figure 1 illustrates the relative contributions of various green construction measures to environmental impact reduction. The chart visually compares the effects of energy efficiency, sustainable material selection, waste minimization, water conservation, and green certification on lowering the ecological footprint of buildings.



As shown in Figure 1, energy efficiency and waste reduction represent the most substantial contributors to decreasing the environmental burden of construction projects. Sustainable material use and water management also play essential roles, while green certification enhances overall performance by promoting best practices. These insights demonstrate that an integrated approach to green construction maximizes environmental benefits. In addition, the use of environmental standards such as Leed, Breeam and the domestic KazGreen system allows for a systematic assessment of the environmental effectiveness of projects. A comparative analysis showed that certified buildings demonstrate a steady reduction in total environmental impact by 35-45% according to four key indicators: energy consumption, emissions, waste and use of materials.

Special attention is paid to the "building life Cycle". The assessment showed that the maximum environmental effect is achieved not only at the operational stage, but also when choosing sustainable technologies for the extraction, transportation and disposal of materials. This confirms the need for an integrated approach to design and construction, focused on minimizing negative impacts at all stages of the life cycle. In general, the results of the study indicate that "green construction" not only reduces the burden on ecosystems, but also contributes to the formation of an ecological culture in society. In the long term, such a strategy ensures the transition to a low-carbon economy, improves the quality of the urban environment and improves public health.

Conclusion. Green construction significantly reduces negative environmental impacts by lowering energy consumption, water usage, carbon emissions, and construction waste. Energy efficiency and waste minimization are the most effective strategies for mitigating the ecological footprint, while sustainable material selection and water management further enhance the environmental performance of buildings. The adoption of green building certifications ensures integrated implementation of best practices, promoting long-term sustainability. Overall, green construction serves as a practical and effective tool for advancing environmental protection in the construction sector.

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