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Semiotics of space in ecological agroarchitecture

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Abstract. In the context of worsening environmental problems, modern architecture is turning to the search for new models of interaction with nature. Ecological agroarchitecture, combining sustainable design, agrotechnology and the philosophy of nature-oriented thinking, is becoming one of the relevant areas. The purpose of this study is to consider the architectural space of the agroecological type as a semiotic system capable of translating the values of sustainability, memory and cultural identity. The work focuses on objects where the principles of bioesthetics, environmental ethics and symbolic expression intersect, such as energy – intensive buildings, memorial complexes and biomorphic pavilions. The methodology is based on an interdisciplinary approach combining architectural semiotics, environmental design and cultural and philosophical analysis. The results show that architectural forms of agroarchitecture have symbolic potential: they visualize natural processes and convey the ideas of cyclicity, rebirth and belonging.

The research contributes to the development of the concept of architectural space as a meaningful system and can be applied in the design of objects integrated into the ecological and cultural context.

Keywords: semiotics, agroarchitecture, architecture, symbolism, sustainability, cultural memory, bioesthetics.

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Introduction

In recent years, environmental issues have been increasingly included in the architectural agenda, forming a new design paradigm focused on human harmony with the environment. Against this background, a special trend is being formed – ecological agroarchitecture, which arose at the intersection of sustainable design, agricultural technologies and the philosophy of nature-based thinking. Architecture in this context is considered not only as a physical shell, but also as an expressive means capable of conveying meanings, images, cultural archetypes and values [1, 2]. It is in this field that the application of the semiotic approach is actualized, which makes it possible to explore architectural space as a system of signs and symbols through which the ideas of memory, interaction with the living and environmental ethics are transmitted.

Despite the growing interest in sustainable construction in Kazakhstan, systemic research combining agroecological architecture and semiotics is still in its infancy. Today, there is a shortage of scientific papers that reveal how architectural forms can perform not only a utilitarian, but also a semantic function – to become carriers of the cultural code and ecological consciousness. This fact underlines the relevance of further research in this area.

The study aims to identify how agroecological architecture is able to perform communicative and symbolic functions, becoming a space of expression of cultural and natural values.

The object is architectural objects of agroecological purpose (including memorial complexes, biomorphic structures and energy – intensive buildings), the subject is the mechanisms and forms of semiotic content manifestation in their spatial organization.

The hypothesis is that the agroarchitectural space can be considered as a complex sign system capable of forming a conscious attitude towards nature, memory and sustainability in humans.

Research objectives include:

– systematization of theoretical approaches to architectural semiotics and agroecodesign;
– analysis of existing examples of spaces integrating semiotic and ecological principles;
– development of methodological foundations for identifying iconic structures in architecture;
– drawing conclusions about the symbolic potential of agroecological facilities.

The methodology

The methodologyis based on interdisciplinary synthesis – a set of methods is used, including:

– architectural and semiotic analysis;
– bioesthetic interpretation of shapes and images;
– methods of sustainable design and cultural coding.

Both theoretical sources and empirical material are used – projects of modern agroecological complexes. Methods of comparative analysis, meaningful interpretation, as well as visual and graphical analysis tools using specialized software are used.

The research material covers both international and Kazakhstani examples of agroecological architecture, presented in various degrees of maturity – from conceptual models to realized objects. Quantitative parameters reflect the scale, structure, and principles of space organization, while qualitative parameters reflect the level of symbolic expressiveness and integration with the natural environment. The present study is not limited to analyzing existing examples, but offers the author's concept of the semiotic code of agroarchitecture, in which architectural forms are considered as carriers of symbolic meanings associated with the cycles of nature and cultural identity. The main hypothesis is that semiotic forms can enhance the ecological perception of the environment, forming an emotional and ethical attitude of a person to nature through architecture.

Findings/Discussion

1. Theoretical foundations of semiotics of architecture and nature

Semiotics, as the science of signs, studies how cultural elements convey information. Architecture is one of the most ancient and stable sign systems in which the physical form carries cultural, emotional, and ideological meanings. Space becomes a communication platform that transmits messages through form, material, composition, color, scale, and position in the landscape.

The semiotics of architectural space suggests that each element can be considered as a sign.:

• The column can symbolize strength and stability,

• glass facade – openness and transparency,

• A vibrant green facade – interaction with nature and caring for the environment.

When it comes to ecological architecture, the semiotic field becomes more complicated: architectural forms become mediators between nature and culture. Space begins to speak the language of biological processes – growth, photosynthesis, regeneration, symbiosis. These biological and ecological processes become cultural codes, turning into new forms of expression of architectural memory and meaning.

2. Space as a semiotic system in agroarchitecture

Ecological agroarchitecture is a design direction based on the principles of permaculture, symbiotic integration of agricultural systems, the use of natural and recycled materials, renewable energy sources, as well as passive energy conservation technologies. Within the framework of this approach, architecture ceases to be just a living space or a functional structure – it becomes an integral part of ecological processes, capable of self-renewal, interaction with the environment and sustainable existence.

Spatial composition in agroarchitecture is being filled with a new meaning [3]:

1. Roofs are turning into productive green surfaces – urban farms and gardens;

2. Facades acquire the function of "living walls" that filter the air and improve the microclimate;

3. Courtyards and open spaces become ecosystems that support biodiversity.

Each element acquires a symbolic dimension.:

1. The earth is a metaphor for roots, continuity and sustainability;

2. Water is associated with life, purification, and the continuous passage of time.;

3. Plants symbolize growth, transformation, and the cyclical nature of existence.

In this context, the architectural space loses its neutrality and becomes an expressive mediator of meanings. It begins to "speak" – visually, symbolically and ecologically, forming a new sign system where each element carries a message of care, memory and unity with nature.

Thus, in agroarchitecture, semiotic forms act not only as metaphorical, but also as functional structures. For example, biomorphic pavilions not only symbolize organic life but also serve as microclimatic systems that regulate humidity and temperature. This allows us to talk about a bio-semiotic synthesis, where the sign and function coincide: the environmental efficiency of an object becomes its symbol. The research suggests a classification of such forms: Bioiconic shapes – visually refer to natural structures (leaf, spiral, root), ecosymbolic forms express the principles of cyclicity, regeneration, and closed circuit, memorial forms create a connection between nature, memory and the cultural code of the territory.

3. Memorial forms in agroarchitecture: Meaning, innovation and symbolism

The Flora Robotica Project

The Flora Robotica project is a biohybrid system that combines living plants and distributed robots to create architectural objects and spaces. The project aims to develop living architectural systems with functions of self–healing and self-organization. Robots and plants work together to form organic structures that adapt to the needs of their inhabitants.

Figure 1,2. Images of robots caring for plants and fruits
(https://www.bayer.com/en/agriculture/article/smart-farming-revolution)

Energy-efficient buildings as an architecture of ecological memory

The Broom building in Finland

The Broom building in Joensuu, built in 2004 for the Finnish Forest Research Institute, is an example of energy-intensive architecture. Wood was chosen as the main material for the construction, which emphasizes the concept of sustainable development and the recycling of materials. The building has received several awards for innovative use of wood and energy conservation.

Figure 3. The Broom building
(https://ru.wikipedia.org/wiki/%D0%A4%D0%B0%D0%B9%D0%BB:Metla2009.jpg)

CopenHill Plant in Denmark

CopenHill in Copenhagen is a waste–to–energy plant that combines environmental and community functions. There is a ski slope on the roof of the factory, and a climbing wall adorns the

facade. The building is equipped with a green roof, contributing to the creation of an urban ecosystem and improving air quality.

Figure 4. CopenHill plant
(https://www.architonic.com/es/story/solarlux-the-winners-of-the-design-educates-awards-will-be-honoured-at-architecture-in-foyer-/20218549)

Memorial pavilions and gardens: Spaces of silence and memory
Ryazan VDNH in Russia

Ryazan VDNKH is an exhibition complex built in 1955 to showcase the achievements of the national economy. The complex includes 22 pavilions in the late Stalinist Empire style, spread over an area of 9.6 hectares. In 2021, the ensemble received the status of an architectural monument and was taken under state protection.

Figure 5. Ryazan VDNKh
(https://fondvnimanie.ru/news/81/vlasti-sdelali-pervyy-shag-k-spaseniyu-ryazanskoy-vdnh)

The City of Migratory Birds project in Kazakhstan

The City of Migratory Birds project is being implemented in Kostanay, aimed at creating public spaces symbolically associated with various bird species. Each square or park represents a particular bird and includes elements reflecting its characteristics. The project promotes environmental education and the formation of a green framework of the city.

Figure 6. View of the city of Kostanay (https://designer.kz/2024/11/kostanay-is-a-city-of-migratory-birds/?ysclid=m9q3hwc8h364140952)

4. Conceptual and design proposals

Based on the analysis, the author has developed a conceptual model of “Eco-SemioSpace”, suggesting that an architectural space can be considered as a system of signs, where each element carries a certain meaning.:

1. The material symbolizes origin and resourcefulness (for example, clay = locality, wood = life, metal = adaptability);
2. The form expresses a person's attitude to nature (open forms – trust, closed forms - protection);
3. The landscape becomes a text of memory, where plants and water play the role of symbols of time and purification.

The application of this model can become a methodological basis for the design of agroecological complexes in Kazakhstan, especially in areas of restoration of degraded landscapes. This conceptual approach has been tested through the author’s visualization of a memorial park (Fig. 7), demonstrating how form, material and landscape can embody symbolic meanings in real design practice.

Based on the above examples, several areas of innovative architectural solutions can be identified:

1. Potemkin Memorial Agropark – integration of steel and natural elements to create a space of reflection and connection with nature [4].

2. Biohybrid pavilion "Flora Robotica" – the use of living plants and robots to form adaptive and self-organizing spaces.

3. Energy – efficient Broom building - the use of wooden structures and sustainable technologies to reduce energy consumption and environmental impact.

4. CopenHill plant with public functions – transformation of an industrial facility into a center of public life with ecological and recreational areas.

5. Memorial Complex of Ryazan VDNH – preservation and restoration of the historical exhibition complex as a monument of architecture and culture.

6. The ecological project "City of Migratory Birds" is the creation of thematic public spaces dedicated to various bird species in order to raise environmental awareness and improve the urban environment.

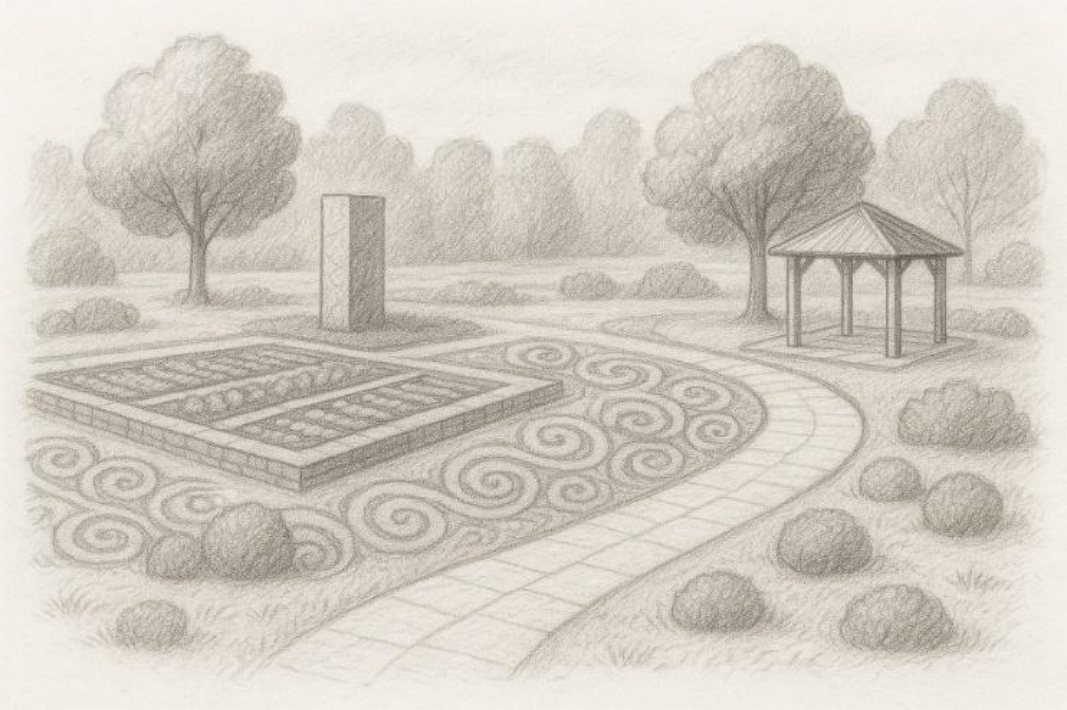

Figure 7. Conceptual sketch of an eco-semiotic memorial park in Kazakhstan. The composition reflects the principles of Eco-SemioSpace, where landscape forms, materials, and ornaments embody ideas of nature's cyclicity, memory, and sustainability, created using a neural network: https://www.artguru.ai/ru/

The image shows a small memorial complex made in the spirit of ecological agroarchitecture using Kazakh ornamental semiotics. The space is organized in the form of a master plan, where the shapes of the landscape, paths, ponds and green spaces refer to the traditional symbols of Kazakh culture. The central element is a pyramid-shaped monument with an ornament symbolizing the spiritual connection of generations. Nearby there are areas with vegetation, decorated in the form

of stylized ornaments and waves, which emphasizes the idea of the unity of nature, memory and cultural identity [5].

5. Future Perspectives and Educational Potential of Agroarchitecture

The methodology proposed by the author for interpreting architecture as a semiotic system can be used in the design of educational and memorial agroecological spaces in Kazakhstan. For example, on academic campuses, landscaping elements and water bodies can carry symbolic meanings of national culture, forming an emotional connection between students and nature.

One of the underexplored aspects of ecological agroarchitecture is its potential in educational and research environments. Agroarchitectural spaces, with their capacity to demonstrate natural processes, energy efficiency, and ecological harmony, can become platforms for immersive learning [6]. Schools, universities, and research centers designed on agroecological principles can serve as interactive laboratories, where students and the public learn about sustainability through direct experience.

Figure 8. Schematic conceptual image of the author, created using a neural network: https://www.artguru.ai/ru/

Such educational agrocomplexes may include:

1. Greenhouses powered by solar energy
2. Hydroponic and aquaponic systems
3. Wind energy stations
4. Thematic green learning zones with symbolic design elements

The design of these campuses can incorporate semiotic elements that reflect the values of environmental consciousness, responsibility, and innovation.

A vivid example is the “Earthship Academy” (USA), a self-sufficient educational facility where students build and study autonomous buildings made from natural and recycled materials. It introduces sustainable living practices and embeds symbolic meanings of autonomy, renewal, and cyclical balance between humanity and the planet [7].

Moreover, agroarchitecture can significantly influence urban planning, suggesting new hybrid formats of living that merge functionality, memory, and symbolic ecological expression. Future urban eco-districts may feature vertical gardens, rooftop agriculture, and culturally coded public spaces rooted in local traditions. Through architectural semiotics, such developments could communicate ideas of harmony, balance, and collective care for the Earth [8].

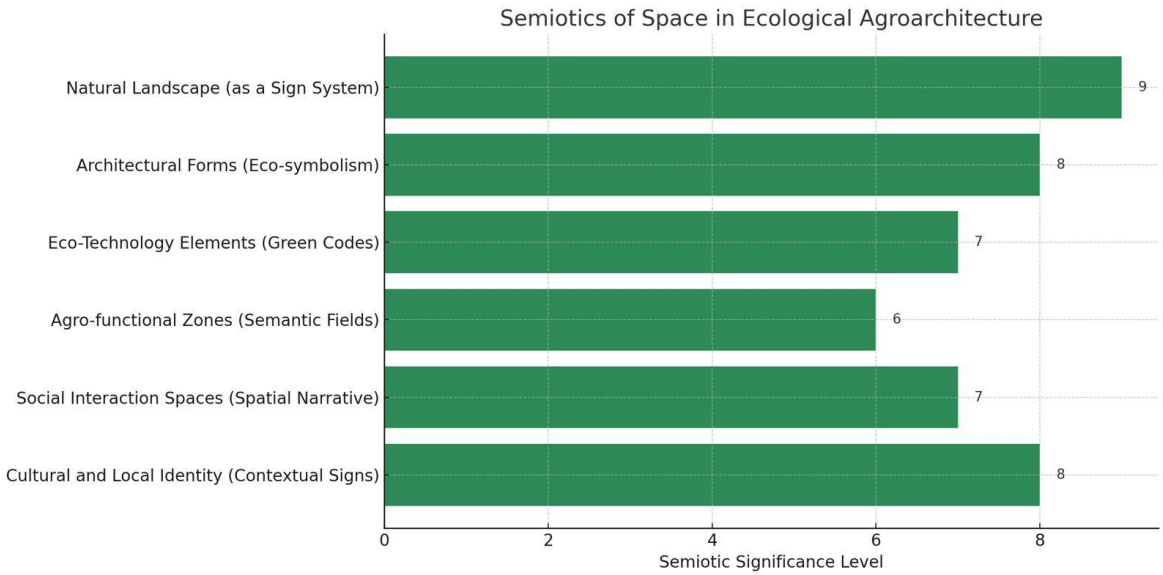

Figure 8. Semiotics of Space in Ecological Agroarchitecture

6. Additional Case Analysis: Earthship Biotecture

Earthship Biotecture, founded by architect Michael Reynolds, represents one of the most symbolic and sustainable directions in global ecological architecture. Built from used tires, glass bottles, and other recycled materials, Earthships are off-the-grid structures.

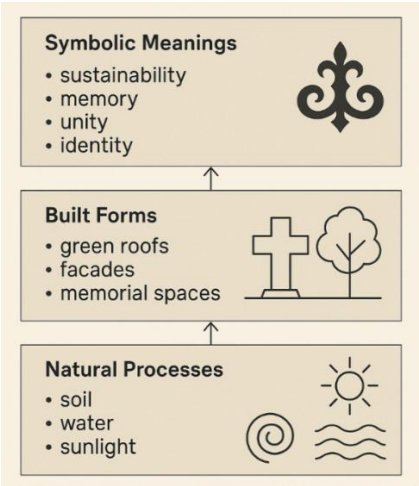

Figure 9. Symbolic Layers in Ecological Agroarchitecture, created by the author

They use:

1. Passive solar heating and cooling
2. Rainwater harvesting

3. Greywater recycling
4. Indoor food production
5. From a semiotic point of view:
6. Glass bottle walls = transparency, illumination
7. Reused tires = resilience, transformation
8. Earth-rammed walls = rootedness and protection

These materials symbolically transform waste into life, turning discarded objects into powerful messages of rebirth, self-sufficiency, and ecological reconciliation. Earthships are not only sustainable but also philosophical statements about how architecture can embody a different way of thinking about human-nature relationships.

Conclusion

In the context of growing global environmental concerns and the search for meaningful architectural responses, the semiotic study of space in ecological agroarchitecture reveals itself as both timely and deeply relevant. This paper demonstrates that agroarchitecture is not merely a convergence of sustainable technologies and rural design elements, but a new cultural and communicative phenomenon **–** a language of space where natural processes, symbols, and architectural forms interact in a unified ecological narrative.

Agroecological architecture goes beyond the utilitarian or technical. It is capable of conveying memory, identity, and environmental ethics through expressive spatial structures. Each element of design **–** whether a green roof functioning as an urban farm, a vertical garden filtering air, or a memorial pavilion rooted in cultural symbolism **–** contributes to a broader dialogue between human beings, nature, and history.

The semiotic approach proves essential in uncovering these hidden layers of meaning. Architecture becomes not only the background for life processes, but an active participant in shaping values and behaviors. Through its forms, materials, and spatial logic, it communicates ideas of regeneration, responsibility, and continuity. By encoding natural metaphors – such as growth (plants), stability (soil), flow (water), and cyclicity (seasons) – agroarchitecture fosters a more intuitive and emotional connection between humans and their environment.

The examples explored – from the Flora Robotica biohybrid systems to the Broom Building, CopenHill, and Kazakhstani initiatives like the City of Migratory Birds – show that architecture can become a living symbol, evolving with its users and surroundings. These projects exemplify how spatial forms can embody memorial potential, energy awareness, cultural heritage, and ecological interdependence simultaneously.

Moreover, the inclusion of local semiotic codes, such as Kazakh ornamental motifs, reveals the potential for architecture to maintain a dialogue between the past and the future, between tradition and innovation. Such a fusion offers a powerful model for architectural thinking in the Anthropocene – one that respects both cultural specificity and global sustainability imperatives.

The research has revealed that architectural elements within agroecological design acquire symbolic depth:

1. Green roofs are no longer mere technical solutions, but metaphors of growth, harmony, and coexistence.
2. Memorial spaces cease to be static commemorations and become living ecosystems of memory, where the past is reinterpreted through nature's processes – cyclicality, regeneration, and transformation.

3. Reused materials (as seen in Earthship Biotecture) not only reduce waste but symbolize rebirth, autonomy, and resilience.

From a semiotic standpoint, agroarchitecture functions as a language of sustainability, transmitting ideas such as the unity of nature and culture, the interconnectedness of people and place, and the redefinition of memory through ecological expression.

Furthermore, the incorporation of Kazakh ornamental semiotics in ecological design (as shown in the "City of Migratory Birds" project) demonstrates the potential of agroarchitecture to preserve national identity while promoting a green future. This synergy between tradition and innovation becomes a model for culturally sensitive ecological development.

In methodological terms, the interdisciplinary approach adopted in this work – blending semiotics, environmental design, bioesthetics, and philosophical interpretation – proves effective in analyzing architecture not just as a structure, but as a carrier of meaning, a space of memory, and a medium of transformation.

Thus, the author's concept of the semiotic code of agroarchitecture allows us to consider ecological forms not only as technical solutions, but also as carriers of meanings capable of influencing human consciousness. The contribution of the research is to develop a model of the relationship between semiotics and environmental design, which opens up new perspectives for creating an architecture that combines ecology, culture and the philosophy of sustainability.

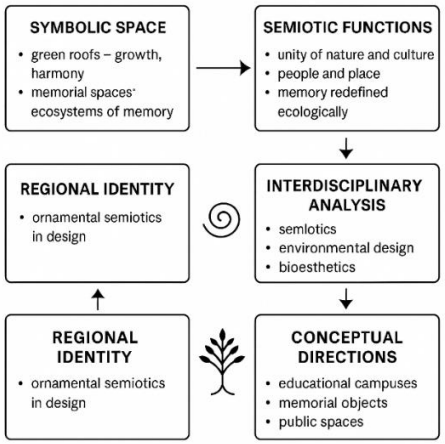

Figure 10. Semiotics of ecological agroarchitecture, created by the author

Research Significance and Contribution

This study contributes to the scientific discourse in several meaningful ways:

1. It systematizes the semiotic functions of agroecological architecture, offering a framework for analyzing space through layers of natural, constructed, and cultural meaning.
2. It identifies case studies (such as CopenHill, Broom, Flora Robotica, and Earthships) that exemplify the living interaction between ecological performance and symbolic resonance.
3. It proposes new conceptual directions for the design of educational, memorial, and public spaces grounded in sustainability and semiotic clarity.

Implications for Practice and Future Research. The practical implications are far-reaching: architects, urban planners, and educators can use the principles outlined in this research to create spaces that are not only environmentally efficient, but also emotionally and culturally expressive.

Agroarchitecture, when understood semiotically, becomes a bridge between generations, between technology and nature, between memory and innovation.

Future research may deepen this direction by exploring regional semiotic codes in ecological design, developing interactive educational campuses based on agroecological principles, and studying user perception of symbolic space in green environments.

Agroecological architecture, when approached through the lens of semiotics, becomes a multilayered language – a system where every space speaks, every form remembers, and every material resonates. It invites us to rethink the built environment not as a neutral container, but as a living mediator of values, stories, and responsibilities. This paradigm opens new pathways for design – where architecture becomes a tool for education, emotional resonance, and planetary care. The future of architecture lies not only in innovation, but in meaning – and agroarchitecture stands at the forefront of this meaningful future.

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The contribution of the authors.

Ostapenko I.I. – data collection and analysis, text writing, team coordination, played a key role in the research methodology.

Seitova N.S. – collecting information, graphic design, writing text.

Dyussenova D.G. – collection of information, methodology, preparation of graphic materials, analysis, and manuscript review..

Yessenbayev A.M. – critical revision, formulation of scientific conclusions, editing of the final text.

All authors reviewed and approved the final manuscript and are responsible for ensuring the accuracy and integrity of the work.

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Семиотика пространства в экологической агроархитектуре

Аннотация. В условиях обострения экологических проблем современная архитектура обращается к поиску новых моделей взаимодействия с природой. Одним из актуальных направлений становится экологическая агроархитектура, сочетающая устойчивое проектирование, агротехнологии и философию природоориентированного мышления. Цель данного исследования – рассмотреть архитектурное пространство агроэкологического типа как семиотическую систему, способную транслировать ценности устойчивости, памяти и культурной идентичности. Работа акцентирует внимание на объектах, в которых пересекаются принципы биоэстетики, экологической этики и символической выразительности – таких как энергопассивные здания, мемориальные комплексы и биоморфные павильоны. Методология основана на междисциплинарном подходе, объединяющем архитектурную семиотику, экологическое проектирование и культурно-философский анализ. Результаты показывают, что архитектурные формы агроархитектуры обладают символическим потенциалом: они визуализируют природные процессы и передают идеи цикличности, возрождения и сопричастности.

Исследование вносит вклад в развитие концепции архитектурного пространства как смыслоносной системы и может быть применено при проектировании объектов, интегрированных в экологический и культурный контекст.

Ключевые слова: семиотика, агроархитектура, архитектура, символизм, экологичность, культурная память, биоэстетика

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Экологиялық агроархитектурадағы кеңістіктің семиотикасы

Аңдатпа. Экологиялық проблемалардың шиеленісуі жағдайында қазіргі заманғы сәулет табиғатпен өзара әрекеттесудің жаңа модельдерін іздеуге бет бұрады. Өзекті бағыттардың бірі тұрақты дизайн, Агротехнология және табиғатқа бағытталған ойлау философиясын біріктіретін экологиялық агроархитектура болып табылады. Бұл зерттеудің мақсаты-агроэкологиялық типтегі архитектуралық кеңістікті тұрақтылық, есте сақтау және мәдени бірегейлік құндылықтарын аударуға қабілетті семиотикалық жүйе ретінде қарастыру. Жұмыс энергия пассивті ғимараттар, мемориалдық кешендер және биоморфты павильондар сияқты биоэстетика, экологиялық этика және символдық экспрессивтілік принциптері қиылысатын нысандарға назар аударады. Әдістеме архитектуралық семиотиканы, экологиялық дизайнды және мәдени-философиялық талдауды біріктіретін пәнаралық тәсілге негізделген. Нәтижелер агроархитектураның архитектуралық формаларының символдық әлеуетке ие екендігін көрсетеді: олар табиғи процестерді бейнелейді және циклдік, қайта туылу және қатысу идеяларын жеткізеді. Зерттеу мағыналық жүйе ретінде архитектуралық кеңістік тұжырымдамасының дамуына ықпал етеді және оны экологиялық және мәдени контекстке біріктірілген объектілерді жобалауда қолдануға болады.

Түйін сөздер: семиотика, агросәулет, сәулет, символизм, экологиялық таза, мәдени жады, биоэстетика

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