

**Pavlo Kobylin**

*PhD (Geography), Associate Professor, Kostyantyn Niemets Department of Human Geography and Regional Studies, V.N. Karazin Kharkiv National University, Svobody Sq., 4, Kharkiv, 61022, Ukraine*  
*e-mail: [pavlo.kobylin@karazin.ua](mailto:pavlo.kobylin@karazin.ua), <https://orcid.org/0000-0001-9718-5838>*

**Liudmyla Niemets**

*DSc. (Geography), Professor, Kostyantyn Niemets Department of Human Geography and Regional Studies, V.N. Karazin Kharkiv National University, Svobody sq., 4, Kharkiv, 61022, Ukraine*  
*e-mail: [ludmila.niemets@karazin.ua](mailto:ludmila.niemets@karazin.ua), <https://orcid.org/0000-0001-9943-384X>*

## HUMAN-GEOGRAPHICAL FEATURES OF THE AGRICULTURAL RESEARCH IN THE ASPECT OF THE EU NATURE RESTORATION REGULATION

The article provides a theoretical and methodological generalization of the human-geographical features of the study of agriculture as a complex, multi-level social and geographical system. The importance of this study comes from the growing role of agriculture in providing food security, helping the economic development of areas, restoring the natural environment and agricultural ecosystems, and the need to fully comprehend how agriculture is changing due to globalization, climate change, and uneven development across regions, as required by human geography.

The aim of the article is to theoretically substantiate and generalize the human-geographical features of agricultural research in relation to the EU Nature Restoration Regulation; to determine its structure and functioning as an open multi-level social and geographical system; and to identify methodological approaches and methods for conducting human-geographical research in agriculture.

The article discusses the primary theories regarding the development and location of agriculture, as well as the key provisions of the EU Regulation on nature restoration. The authors interpret agriculture as a key element of the interaction of social, natural, and economic subsystems that function in the unity of geographical space and time. They analyzed the structure of agriculture with the separation of crop production and livestock production; the functions of agriculture are highlighted: food, raw material, economic, social, environmental, territorial, mentality-forming, cultural, informative, and restorative ones.

The researchers reveal the main methodological approaches in the study of agriculture, namely geographical, systemic, synergistic, informational and historical ones, and justify the need for their comprehensive application for the constant analysis of the agricultural organization in different regions and countries, identifying its specific features and patterns of development. Philosophical, general scientific, and specific scientific methods of the human-geographical research of agriculture are characterized. The obtained results characterize the theoretical and methodological basis for human-geographical research of agriculture at various hierarchical levels, in the development of territorial development strategies, restoration of agricultural ecosystems, and management of agricultural development.

**Keywords:** *agriculture, human geography, social and geographical systems, methodological approaches, research methods, agricultural functions, EU Nature Restoration Regulation.*

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**Statement of the problem.** Agriculture is characterized as one of the key sectors of the economy, contributing to food security and socio-economic development of the territory, forming a raw material base for industry, and playing a leading role in environmental management. At the same time, agriculture is characterized by high spatial differentiation, due to a combination of natural-geographical, historical factors, socio-demographic processes, and economic factors. In addition, agricultural activity significantly affects the state of the natural environment; in particular, it is a source of pollution of soil, water resources, atmospheric air, etc. In this regard, there is a need to restore natural ecosystems, including agricultural ones. The adoption of the EU Nature Restoration Regulation contributes to this process. All this emphasizes the special role of human geography in the study of agriculture as a spatially organized and functionally complex system.

Despite a significant amount of scientific research, approaches to the analysis of agriculture remain fragmented in human-geographical papers. In particular, the interpretation of its essence, structural organization, as well as methodological approaches to the study of territorial differentiation of agriculture remain insufficiently coordinated. Often, attention is focused on individual sectors, regions, or indicators, without a holistic consideration of agriculture as a functional component of the social and geographical system, interacting with natural and socio-economic subsystems.

Contemporary conditions of globalization, climate change, transformation of agricultural markets, and deepening regional differences highlight the need for comprehensive human-geographical studies of agriculture. This involves a combination of sectoral and territorial approaches, analysis of spatial organization, specialization and functions of agricultural activity, as well as



taking into account the influence of diverse natural and socio-economic factors.

Thus, the problem statement characterizes the need for theoretical and methodological substantiation of the human-geographical features of the study of agriculture as a complex, multi-level, open, and dynamic system in the spatio-temporal dimension.

**The aim of the article** is to theoretically substantiate and generalize the human-geographical features of agricultural research in relation to the EU Nature Restoration Regulation; to determine its structure and functioning as an open multi-level social and geographical system; and to identify methodological approaches and methods for conducting human-geographical research in agriculture.

**Theories of agricultural development and location.** Among the well-known theories of agricultural development, it is worth noting *the theory of the agricultural Standort* (in German Standort is location, placement) by the German economist J. Thünen (1783–1850), set out in the paper “The Isolated State in its Relation to Agriculture and the National Economy” (Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationaloekonomie) (1826) [43]. The theory explains spatial location of agriculture depending on the distance to the market and transportation costs. One central city stands out in the “isolated state” mode. He shows that agricultural businesses are in concentric belts around the market: the more costly and perishable the product, the more profitable it is to produce it near the city. With increasing distance, the intensity of agriculture decreases, and extensive forms of land use prevail on the outskirts. J. Thunen identified six belts:

1. vegetable growing, fruit growing, dairy farming;
2. forestry
3. grain crops;
4. fodder crops;
5. three-field crop rotation;
6. on the outskirts - extensive livestock farming and uncultivated land.

The theory is of a conditional nature and applies only to certain regions of Western Europe and some states of the USA [27].

**The theory** of the Swedish geographer *Olof Jonasson* (1894–1965) is a development of J. Thünen's ideas and links the location of agriculture under the influence of land rent, the sales market, and transport. The scientist proved that agricultural production forms concentric belts around urban and industrial centers in Europe and North America. The most intensive and perishable industries tend to be located near the city, while the less intensive ones are located further away. Applying this model to Europe in 1925 and to certain areas of North America, in particular the Edwards Plateau in Texas, O. Jonasson confirmed the universal nature of the model, which was later used by other researchers to assess the intensity of agriculture [30].

The Scottish economist Adam Smith (1723–1790), in his paper “*An Inquiry Into The Nature And Causes Of The Wealth Of Nations*” (1776) substantiated the *theory of absolute advantage*. The scientist analyzed the cost and expenses of production and concluded that interna-

tional trade is due to differences in costs between countries, which manifest themselves in varying degrees of provision with natural conditions, resources, and historical traditions [21, 27, 41]. In the case of agriculture, it means that there are different production efficiencies, so it is advisable for countries to specialize in products with absolute advantages, export them and import other, more expensive goods for the region, rather than strive for complete self-sufficiency.

The English economist David Ricardo (1772–1823) in his paper “*On the Principles of Political Economy and Taxation*” (1817) developed the Adam Smith's views, proposing the *theory of comparative advantage*. The scientist proved that participation in international trade can be beneficial even for a country that does not have the best natural or economic conditions of production. An important element of this theory is the category of opportunity costs, which characterizes the labor time for the production of a certain product. If countries or regions specialize in the production of goods with relatively lower opportunity costs compared to other countries or regions, then trade will be mutually beneficial for both countries or regions, regardless of their level of absolute productivity [21, 27, 40]. Using the example of agriculture, this theory reflects the expediency of a certain territory specializing in products with the lowest opportunity costs and exporting them, while goods with higher production costs are rationally imported.

D. Ricardo also substantiated the *theory of land rent*, linking it to differences in land fertility and location. He proved that rent is a consequence, not a factor, of the price for products, since it is formed as a difference in productivity between better and worse lands. Its growth, in his opinion, intensifies socio-economic contradictions [21].

**The theory of competitiveness and regional clusters** by M. Porter and M. Enright explains how businesses and areas can become more efficient by creating clusters, which are groups of related and competing companies in the same industry that are located close to each other. M. Porter identified four so-called components of success (“diamond of national advantages”), which characterize the state of the environment and competitive advantages of industries and companies. These components are parameters of production factors (skilled labor, infrastructure, etc.), firm strategy, demand parameters, and the presence of related and supporting industries. According to the “diamond of competitive advantages”, the agriculture development is determined by a combination of resource and technological conditions, competition, demand, supporting industries, and the role of the state. Agricultural clusters contribute to innovation, productivity growth, and regional development [8, 38].

**The Heckscher–Ohlin theory** (by Swedish economists E. Heckscher (1879–1952) and B. Ohlin (1899–1979) explains the comparative advantages of countries due to their provision with factors of production, namely labor, capital, land, and natural resources. The specialization of countries in the production and export of certain products is based on the use of resources that are in surplus in a given country, while products requiring scarce factors are imported. In the case of agriculture, it

is manifested in the orientation of regions with a surplus of land and labor to labor- and land-intensive agricultural production, while areas with the higher level of socio-economic development specialize in intensive and technologically complex types of agricultural activity [21, 36].

#### **Analysis of previous research and publications.**

The analysis of previous publications reflects the significant achievements of scientists engaged in human-geographic research on agriculture in Ukraine. Thus, Sosnytska Y. studied the contemporary transformation processes of agricultural production in Volyn region. The scientist analyzed the historical and geographical prerequisites for the formation. She focused on the agricultural sector and the evolution of agricultural transformations up to the post-Soviet period, paying significant attention to natural and climatic factors as well as management forms. She outlined the problems and prospects for the development of the agricultural sector in the region in the context of European integration, in particular through the creation of agricultural clusters and organic farming [24].

Marushchynt A. investigated transformation processes in the agrarian sector of the Kyiv Prydniprovye and their impact on the socio-economic development of the region. The scientist developed theoretical and methodological principles for the human-geographical analysis of such transformations, identified factors influencing them, described institutional, sectoral and territorial changes in agriculture. The scientist also established a connection between the nature of agrarian transformations and the level of socio-economic development of territories and proposed promising directions for the development of the agrarian sector to stimulate the socio-economic growth of the region [12].

Zayachuk M. carried out a comprehensive human-geographical study of the formation, development, and spatial organization of farms in Ukraine. The author analyzed the stages of the formation of farming, its specialization and territorial differentiation under the influence of natural and socio-economic factors, the scale of land use. He substantiated the typology of farms, the feasibility of their clustering, and the development of cooperation. The scientist also outlined the prospects for sustainable farming development, in particular through organic production and integration into international agricultural markets [5].

Kravets T. carried out a comprehensive analysis of the transformations of the agrarian sphere as a multi-component socio-economic system. The scientist substantiated the concept and types of agrarian transformations, improved the classification of development factors, and also carried out transformational agrarian regionalization of the Lviv region. Based on the SWOT analysis, he determined strategic goals for the development of the agrarian sphere of the region, aimed at increasing competitiveness, improving the environment, and socio-demographic development [9].

Sarkisov A. analyzed the dynamics of transformation processes and development trends of the agro-industrial complex of Kherson region, investigated changes in the structure of the agro-industrial complex, management forms, land ownership, and specialization

of production, and established aspects of the dominance of crop production and the decline of livestock farming. The scientist found differences in where agricultural production is located and explained the need for new development ideas, better irrigation methods, and the creation of agro-industrial clusters as a promising way to help the region grow [23].

Moroz I. developed a methodology for human-geographical research of investment activity in agriculture and the food industry and systematized the factors of investment attractiveness of agro-food production. The author analyzed the territorial differentiation of investments, identified regional clusters by the level of investment saturation, and substantiated the directions for improving the territorial organization of investment activity in the agro-industrial complex [14].

Sukhy P. investigated the formation and evolution of the agro-food complex of the Western Ukrainian region and substantiated its scientific and methodological principles in the conditions of agrarian reforms. The author analyzed the territorial organization and integration processes of the agro-industrial complex, organizational and legal forms of management, and the current state and spatial features of agriculture, as well as the role of the food industry and the agro-food market. The scientist described the parts of the overall agricultural ranking for the administrative districts of Western Ukraine and suggested ways to improve specialization and further develop the complex [25].

Grekov S. carried out a human-geographic analysis of agricultural production in private farms in the Chernivtsi region. He characterized the sectoral and territorial structure of agricultural production, productivity and the role in the formation of the food market, revealed the influence of natural and socio-economic factors and identified territorial disparities between production and the needs of the population, and substantiated the directions for improving the development of farms [2].

Lavrynenko S. developed theoretical and methodological principles for the study of the regional agro-food market. The author revealed the essence and structure of the agro-food market of the Poltava region and analyzed the complex influence of organizational-legal, natural-environmental, and socio-economic factors on its formation. The scientist assessed the territorial differentiation of demand and supply, typified local markets, characterized the main commodity segments (grain, sugar beet, meat, and dairy), and identified key areas for optimizing the territorial organization of the agro-food market, in particular through the creation of a regional food cluster [10].

Penyuk S.'s research focuses on the prerequisites for agricultural development, its branch-functional structure, and areas for improvement. The scientist revealed the territorial-functional structure of agriculture, identified agricultural subregions, and characterized the problems of its improvement [19].

Zablotsky B. revealed the essence and structure of the agricultural land reclamation complex and the methodology of its economic and geographical research. The scientist analyzed the influence of natural resources and socio-economic factors on the land reclamation disorder, carried out a systemic and structural analysis of the agri-

cultural land reclamation complex of the Ternopil region and substantiated recommendations for improving its territorial organization [4].

Levada O.S. established the theoretical and methodological foundations of the environmental approach to rationalizing environmental management and analyzed how the spatial organization of the territory relates to agricultural land reclamation in the Zaporizhia region. The scientist identified the types of environmental management, their environmental features and consequences, carried out environmental and land reclamation zoning of the territory, and outlined the prospects for the rationalization of agricultural environmental management [11].

Despite the significant scientists' achievements in human-geographical studies of agriculture, there are unresolved issues that require further research. In particular, this concerns the analysis and improvement of the conceptual and terminological apparatus, which differs in research. For example, there are such terms as "agrarian sphere", "agro-industrial complex", "agro-industrial territorial systems", "agrarian cluster", "agrarian sector", "agribusiness", "agrarian infrastructure", "agrarian ecosystem", "agrarian market", etc. in human geographers' papers. There is a need to distinguish these concepts.

An important component of agricultural research is the achievements of the international community, in particular, the provisions of the EU Regulation "On nature restoration" (Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869 (Text with EEA relevance) are very important. The European Parliament adopted the document on 17 June 2024, and it came into effect on 18 August 2024. The main objective of the regulation is to establish rules that will contribute to the restoration of at least 20% of the EU's land and 20% of its marine areas by 2030 and all ecosystems in need of restoration by 2050. This regulation will contribute to creating opportunities for long-term and sustainable restoration of biodiversity, the resilience of nature, achieving the EU's climate mitigation and adaptation goals, increasing food security, and implementing the international obligations. The regulation deals with agriculture in Articles 10 "Restoration of pollinator populations" and 11 "Restoration of agricultural ecosystems". In particular, Member States must increase the diversity of pollinators and halt the decline of pollinator populations by 2030 at the latest, and subsequently achieve a trend of increasing pollinator populations. Member States must also implement measures to restore biodiversity in agricultural ecosystems, taking into account climatic and socio-economic conditions. By 2030, it is proposed to ensure an increasing trend in two of the three indicators (meadow butterfly index, organic carbon stock in mineral soils of arable land, share of agricultural land with a high diversity of landscape features), and phased targets are set for increasing the agricultural land bird index and restoring drained peatlands by rewetting [35, 39].

Some issues of restoration of natural systems and agricultural landscapes were considered in T. Pohrebskyi et al.' papers (when studying the transformations of greenfields in Ukraine) [37], Vila Subiros et al. (when studying the impact of the Russian invasion on the ob-

jects of the nature reserve fund) [42], Kostrikov, S. et al. (when determining the impact of military actions on the urban environment) [32], Kuzyshyn A. et al. (when studying the transformation of brownfields in Eastern Ukraine) [33], Morar, C. et al. (when analyzing the spatial and temporal analysis of urban green zones) [34].

#### **Presentation of the main material.**

**The essence of agriculture, its structure.** In general, *agriculture* is interpreted as a branch of the national economy or a branch of the economy where products of plant and animal origin are created, which provide the population with food and raw materials for some industries (textile, footwear, perfumery, food, etc.) [3, 11]. Some scientists also include primary processing of products in agriculture [3]. Human geographers always emphasize the territorial aspect of agricultural development. Thus, Pistun M.D. uses the term "*territorial organization of agriculture*", which denotes the forms of territorial location of agricultural industries, various types of farms and a system of practical socio-economic, technological, and organizational measures for the integrated use of the territory [1].

The structure of agriculture traditionally divides into two categories: crop production and livestock production (Fig. 1). The State Statistics Service of Ukraine considers crop production a branch of agriculture engaged in the growth of cultivated plants. It provides the population with food, livestock with feed, and industry with raw materials [22]. The Statistical Department of the Food and Agriculture Organization of the United Nations (FAOSTAT) identifies 11 groups of crops [18]. Separately, after analyzing the crops, we grouped them and identified 9 groups of crops: cereals (wheat, barley, buckwheat, etc.), fiber crops (flax, agave, jute, etc.), legumes (beans, chickpeas, peas, etc.), fruit crops (apples, apricots, bananas, etc.), oil seeds (sunflower, olives, peanuts, etc.), vegetables (peppers, cucumbers, eggplants, etc.), sugar crops (sugar beets and cane), tree nuts (hazelnuts, pistachios, almonds, etc.), root and tuber crops (cassava, potatoes, yams, etc.).

The State Statistics Service of Ukraine considers livestock production as a branch of agriculture that deals with the breeding and use of farm animals. It provides people with food, raw materials for industry (food, textile, pharmaceutical), as well as organic fertilizer, namely manure [26]. After analyzing livestock crops, we concluded not to group them but to indicate them separately (for example, cattle, pigs, donkeys, bees, bison, camels, etc.) [18].

**Agriculture as a functional component of the social and geographical system.** Since the object of study of human geography in general is the landscape shell of the Earth, where human activity plays an important role in its transformation, the key methodological problem of human geography, according to O.G. Topchiev, is the issue of studying the interaction of society with nature [28]. In this regard, Niemets L. substantiated and formulated the concept of the "social and geographical system", which is interpreted as "... a heterogeneous system containing social elements or subsystems of different levels of generalization and hierarchy, as well as technogenic, mineral, and biogenic elements (subsystems) that interact through flows of matter, energy, and information

in the geographical space-time continuum” [17, p. 113]. The social and geographical system consists of a social subsystem (society), natural (biota and abiota) and economic ones. Social subsystems interact with natural ones

through the process of environmental management and restoration, and the economic subsystem is a channel of direct and reverse links between society and the natural environment [17].

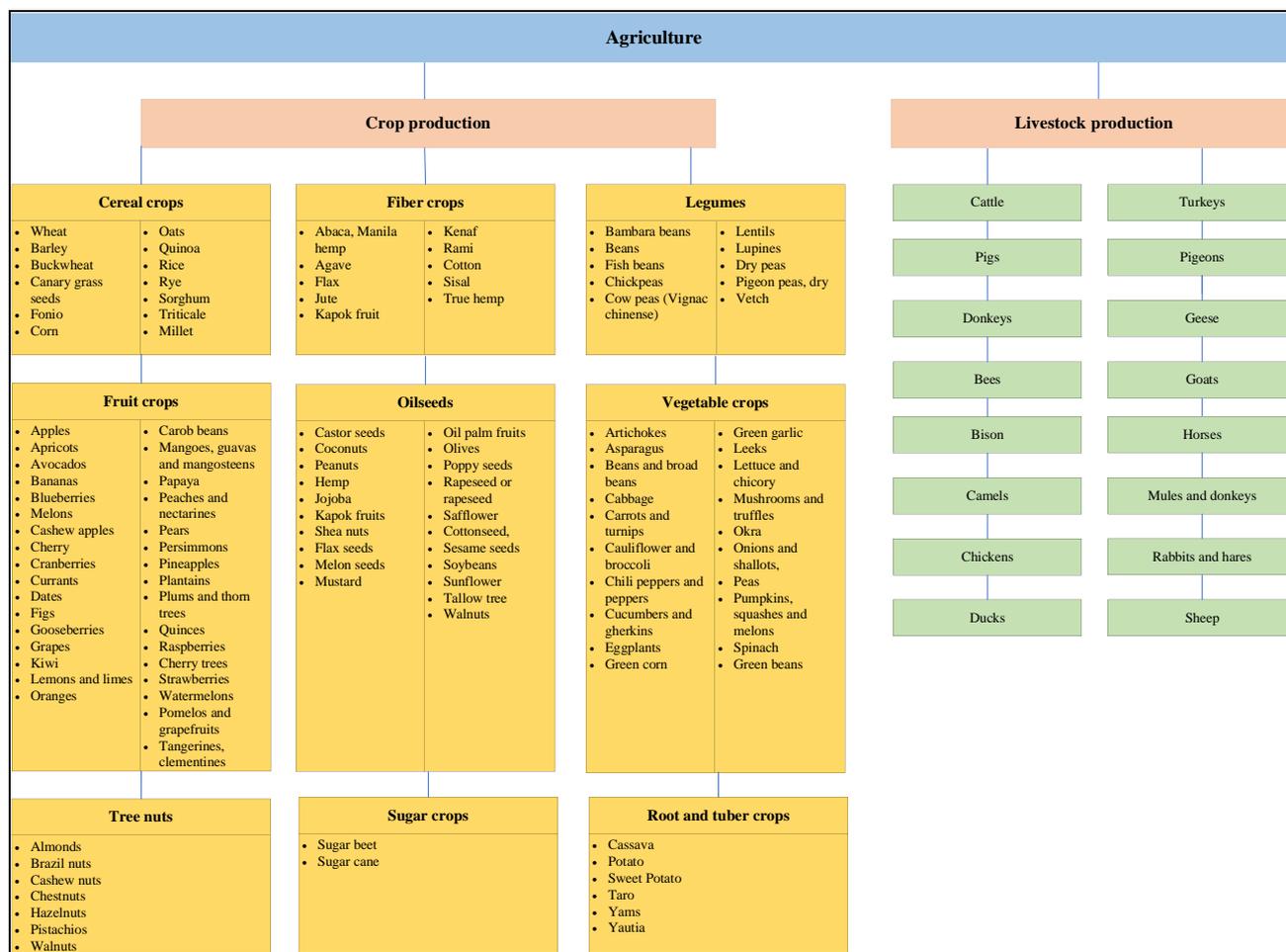


Fig. 1. Structure of agriculture (constructed by authors by data [18])

Agriculture occupies an important place in the structure of the social and geographical system (Fig. 2). Society (social subsystem) is the initiator, generator, and active participant in environmental management and the main consumer of its results [6, 15], formulates the need for food, and industry workers are a labor resource determining the level of the development of agriculture, its quality, and efficiency [7]. The natural environment is a source of meeting population’s social needs [6, 15], the basis for conducting agricultural activities, since natural resources (land, climate, water, etc.) largely determine the development level of agriculture and its types in certain geographical regions [7]. The economic subsystem is considered the executive system of society, which is a tool for its management and influence on the natural environment [6, 15]. Agriculture is a component of the economic (executive) system and plays the role of a channel of interaction between the natural and social subsystems, ensuring the food needs for the population and raw materials for industry [7].

Therefore, we observe powerful and important relationships between social, natural subsystems and agriculture. Other links are also important and characterize the

external environment of agriculture and ensure the functioning of the industry.

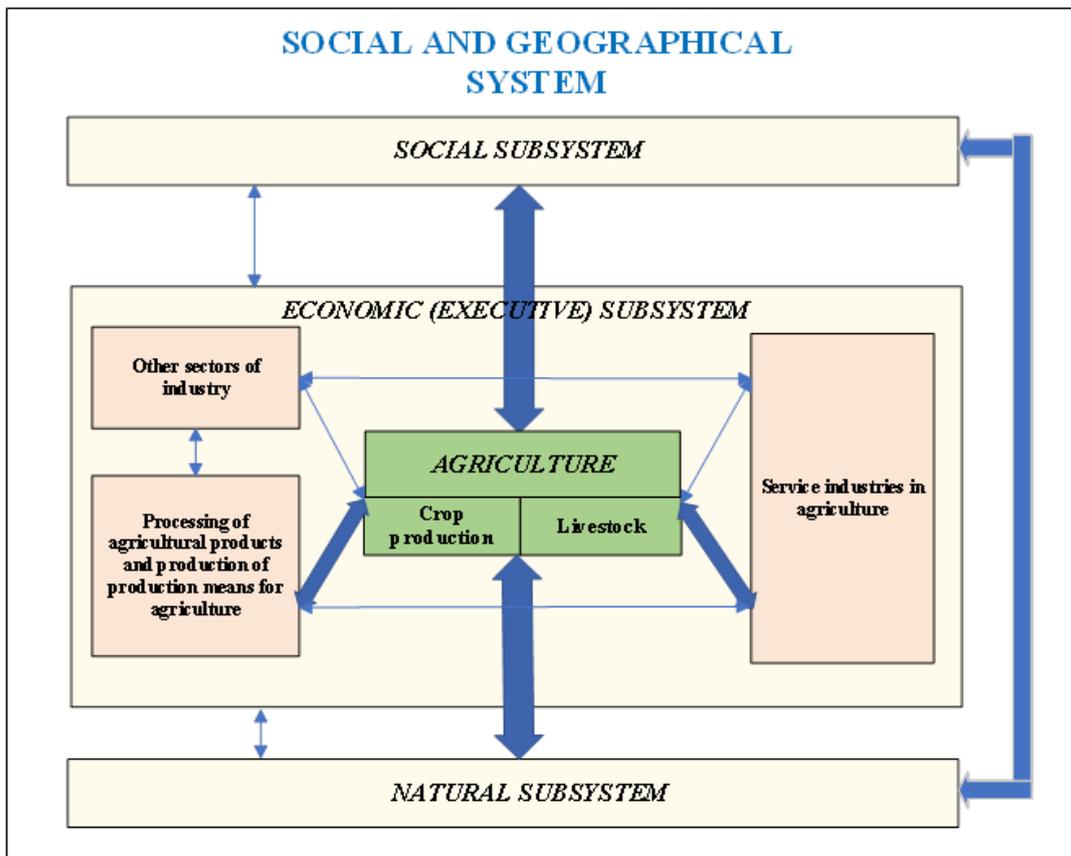
In our previous papers, having considered the place of agriculture in the social and geographical system from the perspective of human geography, we interpreted agriculture as a functional component of the social and geographical system of various hierarchical levels, consisting of subsystems of crop and livestock production, which interact through flows of matter, energy, and information in the geographical spatio-temporal continuum with other sectors of the economy and function under the influence of various natural, geographical, and socio-economic factors in order to meet the population needs in food products and raw materials for industry [7].

**Functions of agriculture.** Agriculture is one of the key sectors of the national economy, as it performs a complex of important functions ensuring the vital activity of society and sustainable development of the state. Its role is not limited to food production but covers economic, social, cultural, environmental, and territorial aspects of development. Let us consider the functions of agriculture in more detail (Fig. 3).

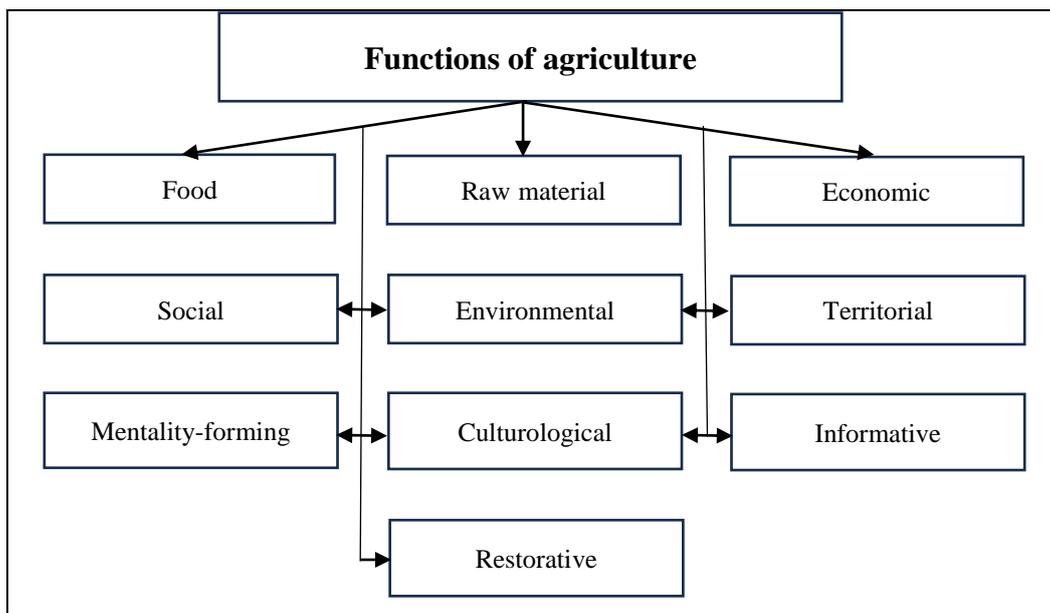
The food function of agriculture characterizes the

provision of food to the population and is the basis for increasing the level and quality of life of the population, people's health, and demographic stability. The food function contributes to the formation of food resources, ensuring food security, meeting domestic demand, reducing import dependence, and promoting sustainable socio-economic development.

*The raw material function* of agriculture is to provide raw materials to the processing industry. The implementation of the raw material function contributes to the development of the processing industry, the growth of gross added value, and the overall socio-economic development of the country/region.



*Fig. 2. Agriculture as a component of the social and geographical system (compiled by the authors based on data [7, 16, 17])*



*Fig. 3. Functions of agriculture*

**The economic function** characterizes the contribution of agriculture to the national economy through budget revenues, job creation, and the development of related industries. Agricultural production provides added value, economic growth, and increased well-being of the population, making agriculture an important factor in the sustainable development of the country.

**The social function** of agriculture is to provide employment and social stability, especially in rural areas. It contributes to the preservation of rural communities, the infrastructure development, the reduction of unemployment, and the containment of migration.

**The environmental function** of agriculture characterizes the rational use and conservation of natural resources. The use of environmentally friendly technologies and rational land use reduces the negative impact on the environment and ensures the sustainable development of agriculture and the natural environment as a whole.

**The territorial function** of agriculture is the development of rural areas and rational use of land resources as a component of the natural environment. Agriculture characterizes the specialization of regions and affects the distribution of the population, the resettlement system, and the economic development of territories. It contributes to the development of infrastructure and the reduction of territorial disparities.

**The mentality-forming function** of agriculture characterizes the formation of values and worldviews of society, which ensures a responsible and caring attitude to nature, native land, and agricultural landscapes. The upbringing of the environmental culture, respect for the land, and the transfer of land use traditions between generations contribute to the transformation of anthropocentric values of society to nature-centric ones, the formation of a mental basis for sustainable development at different hierarchical levels.

**The culturological function** of agriculture characterizes the formation and preservation of the culture of various social groups through agricultural traditions, lifestyle, system of values, knowledge, and skills of management. This also applies to the transfer of cultural experience between generations, the influence of agriculture on art, the formation of cultural landscapes, the promotion of the socialization of the individual, and the preservation of humanistic and environmental values.

**The informative function** of agriculture is to create, collect, process, accumulate, transmit, and use information. It becomes a determining factor in the effective functioning of agriculture and management of the development of rural areas. This function is implemented through information exchange between natural subsystems, socio-economic structures of agriculture, society, and the natural environment and ensures adaptation of economic activity to natural conditions and minimization of environmental risks. An important role is played by managerial information, which flows at all levels of agricultural management and it is the basis for planning, forecasting, and regulating its development.

**The restorative function** of agriculture is to preserve and restore the natural basis of agriculture (soil, water resources, biodiversity, etc.) in order to ensure the

long-term development of the industry. This function is aimed at minimizing the negative impact of economic activity on the environment and restoring disturbed ecosystems. It has an integrative nature, as it creates the prerequisites for the implementation of previous functions (food, raw material, economic, social, etc.) and, thus, contributes to the coordination of socio-economic and environmental interests in the "human-nature" system. With the adoption of the EU Nature Restoration Regulation, this function of agriculture becomes particularly important, since the Regulation forms the institutional conditions for the transition of agriculture to models of sustainable and nature-oriented development.

**Methodological approaches to the study of agriculture.** The human-geographical approach is methodologically appropriate for the study of agriculture, as it is considered a complex, multi-component, and spatially differentiated socio-economic phenomenon. It provides a comprehensive analysis of the territorial organization of agriculture, taking into account natural conditions, socio-demographic, economic and institutional factors characterizing the level and features of agricultural development in different regions/countries of the world. Spatial analysis allows identifying patterns of territorial differentiation, specialization, and productivity of agricultural activity.

Within the human-geographical approach, agriculture is considered as a functional component of the social and geographical systems of different hierarchical levels, which functions as an open system with stable internal and external connections. The combination of geographical, systemic, synergistic, informational, and historical approaches allows studying the interaction of agricultural elements, its adaptive capabilities, the non-linear nature of development, and spatio-temporal dynamics, which is a necessary basis for informed forecasting and making managerial decisions. So let's consider these approaches in more detail.

**The geographical approach** in human geography involves a comprehensive study of the object, considering its spatial organization and territorial heterogeneity. In the study of agriculture, it includes the analysis of not only production but also demographic, social, and economic factors. The spatial aspect is implemented through the identification of territorial differentiation of agricultural processes and modeling of indicators using GIS, trend analysis, and mathematical methods [15, 29].

**The system approach** in human-geographical research involves considering objects as complex, multi-level, and open systems with close relationships between elements [29]. According to Topchiev O., a system is a set of interconnected objects forming integrity and a new quality [28]. In this context, agriculture should be considered as a functional component of social and geographical systems of different hierarchical levels.

The most complete systemic nature of agriculture is manifested in the example of the agro-industrial complex, which unites enterprises of various forms of ownership, farms and personal farms, labor resources, production and transport infrastructure, and agricultural landscapes, as well as institutional and managerial structures. Their interaction forms subsystems of different

levels, namely crop production, livestock farming, product processing, agricultural logistics, etc.

Agriculture as a system is characterized by stable production, economic, technological, resource and informational connections that arise in conditions of cooperation, competition, and determining its spatial organization and territorial differentiation.

An important systemic property is emergence, i.e., the formation of new qualitative characteristics, in particular, aggregate productivity, stability, and adaptability, which arise as a result of the interaction of all components, but not as a simple sum of the results of their functioning [15].

Hierarchy is another basic feature of agriculture as a system [29]. It functions as a subsystem of the economic complex of a region or country, while including lower-level subsystems, namely individual industries, production structures, and territorial agrarian complexes. Each of them has its functions and managerial mechanisms.

As an open system, agriculture constantly interacts with the natural, economic, and social environment, exchanging matter, energy, and information and adapting to climate changes, market conditions, in particular international markets, demographic processes, state agrarian policy, and technological development [15]. Within the framework of system analysis, internal adaptation is distinguished, which reflects the structure and interaction of subsystems, and external adaptation, characterizing the relationship of agriculture with other sectors of the economy, the natural environment, and society, as shown in Fig. 1, as well as its reaction to external influences and managerial decisions.

*The synergetic approach* in human-geographical research is based on the principles of synergetic science as a science of the interaction of elements in complex systems and their self-development. In contrast to the systems approach, which considers the object of research as a holistic, relatively stable system with an ordered structure and predictable connections between elements, the synergetic approach focuses on open, nonlinear systems capable of self-organization, in which development occurs through instability, chaos, and abrupt changes [31]. Within the framework of agricultural research, this approach involves the analysis of internal relationships between elements of the agriculture/agro-industrial complex, as well as the identification of internal resources and mechanisms determining its evolutionary potential.

Agriculture is considered a heterogeneous and multi-component system. Its development is determined by the interaction of natural, economic, social, and institutional factors. The synergistic approach focuses not only on the totality of these factors but primarily on the nature of their interaction, which forms new systemic properties of agriculture. This is very important in contrast to the systemic approach.

From the standpoint of synergetics, the agriculture development is nonlinear and occurs through a sequence of phase transitions at bifurcation points, when the system is rebuilt and chooses one of the possible directions of further development under the influence of external or internal changes. The identification of such points is important for assessing transformation processes, possibilities of restoring agricultural ecosystems, and predict-

ing the prospects for the development of agriculture [15]. This is an important task of human geography; it methodologically has the ability to identify these bifurcation points in the development of agriculture.

*The informational approach* in human-geographical research is aimed at studying the processes of information exchange within the system and between systems. In the study of agriculture, it involves the analysis of information flows both within the agro-industrial complex and in its interaction with other components, namely industries, services, government agencies, the natural environment, and the social subsystem. Information circulates through management, production, and communication channels, ensuring coordination of actions of system elements, its adaptation to changes, and preservation of integrity [6].

In agriculture, information exchange involves the collection, analysis, and transmission of data on resources, technologies, soil and crop conditions, weather risks, yields, prices, logistics, and regulatory requirements. The nature and results of such exchange are determined by management objectives, namely production planning, risk reduction, efficiency improvement, and food security. Information is the basis of management, and the transformation of information is carried out in the following sequence: structural → monitoring → operational → management → structural, when monitoring data are transformed into managerial decisions changing parameters of the system [16].

The intensity and quality of information interaction affect the level of orderliness and adaptability of agriculture. The accumulation of relevant information contributes to the development of the system, while its loss or distortion reduces manageability and can cause degradation processes. For quantitative assessment of the state and dynamics of the agro-industrial complex, the information approach involves the use of information entropy indicators as indicators of heterogeneity, orderliness, and adaptation potential [6, 15].

*The historical approach* in human-geographical research is based on the consideration of the development of geographical objects in space and time, treating phenomena and events as dynamic processes. In the context of agriculture, it involves the analysis of agricultural processes as a certain phase of long-term development with certain prerequisites in the past and possible trajectories of changes in the future, considering existing and possible bifurcation points in social and geographical systems [15].

The study of evolutionary transformations in agriculture, including the structure of production, land use, productivity, specialization, technological change, and the impact of agricultural policy, allows identifying persistent trends and turning points that affect the current state of the industry. It requires an increase in the validity of forecasts, contributes to the early detection of risks, and is important for making managerial decisions [15].

**Methods of human-geographical research of agriculture.** In accordance with the established methodology, a complex of philosophical, general scientific, and specific scientific research methods has been applied in the study of agriculture (Fig. 4) [28, 29]. Their use in human geography is due to the complexity of agriculture

as a functional component of the social and geographical system and the need for its comprehensive analysis in the spatio-temporal dimension.

**Philosophical methods** are used to solve strategic research tasks, in particular, formulation of the goal and scientific objectives, logical construction of the study, application of basic categories, concepts, selection of optimal methods of analysis, as well as ensuring the

reliability of results and conclusions [29]. The leading one among them is the *dialectical method*, which allows identifying and analyzing internal contradictions in the agriculture development, primarily between the socio-economic needs of society and natural resource features and limitations, as well as justifying possible directions for their reconciliation.

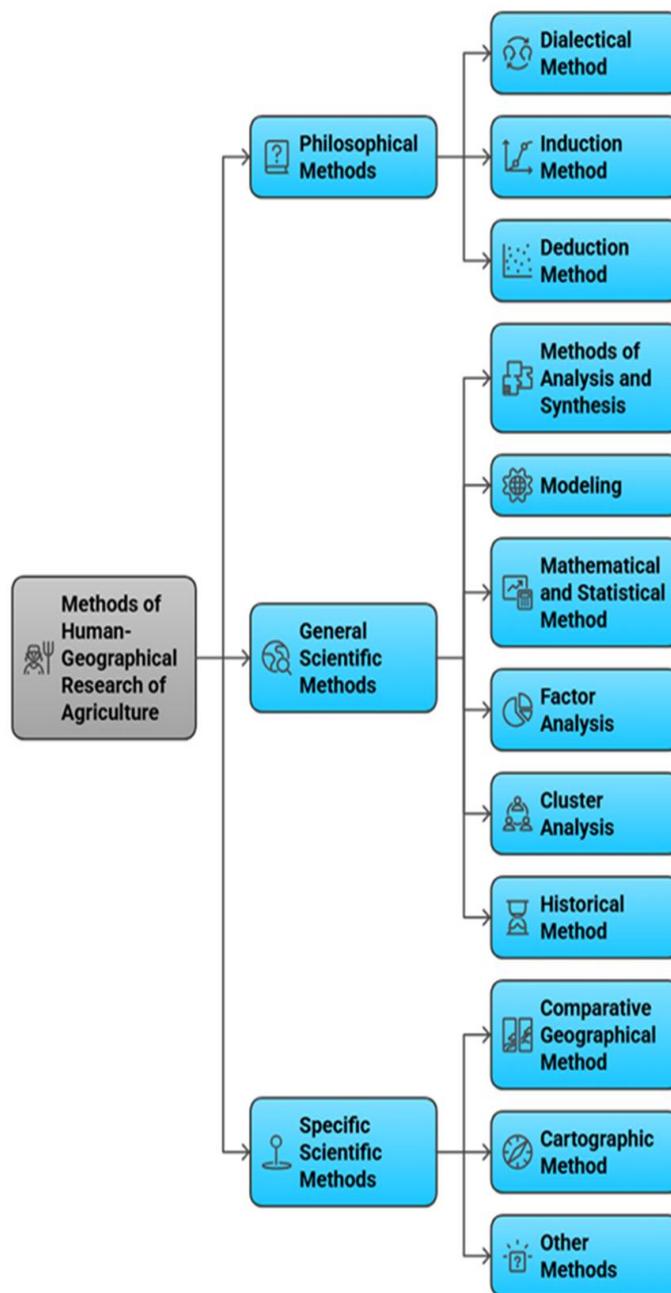


Fig. 4. Methods of the human-geographical research of agriculture (compiled by the authors based on data [28, 29])

The *induction* method is used to generalize empirical data and intermediate results, identify patterns and trends in the functioning of agriculture in the spatio-temporal dimension. The *deduction* method allows reconciling the obtained results with the theoretical provisions of human geography and apply them in other regional or country studies [28].

**General scientific methods** characterize research

methods that, with certain changes and refinements, are used in all sciences [28]. Methods of analysis and synthesis provide a phased study of agriculture: from the identification of key features and factors to the formation of a generalized idea of its functioning as a holistic system.

The *modeling method* is used to replace real agricultural processes with their simplified analogues in order

to identify the main patterns of functioning and development of agriculture for comprehensive analysis and further prediction.

*Mathematical and statistical methods* use the provisions of probability theory and mathematical statistics and are used to process empirical data, analyze relationships between indicators, and implement individual models. Examples of mathematical and statistical methods include factor and cluster analysis. *Factor analysis* is used to identify generalized (latent) factors determining the level and directions of agricultural development based on the analysis of correlations between statistical indicators. *Cluster analysis* is used to group territories according to the principle of similarity of their development in a multidimensional characteristic space. It allows identifying spatial differentiation and the typology of agricultural development [29].

*The historical method* is based on the comprehension that agriculture was formed along with the development of society and is a dynamic system constantly changing, going through successive steps and stages of development [28]. Using the historical method in studies of agriculture helps to track changes and patterns in key aspects, understand the reasons behind the current state of agriculture, and support ideas for its future development.

*Specific scientific methods* are used in individual sciences or in related groups of scientists [28, 29]. Among specific scientific methods, comparative geographical and cartographic methods occupy an important place. The *comparative geographical method* is used for spatial comparison of the level and features of agricultural development between countries/regions/administrative-territorial units. Researchers use the cartographic method and GIS technologies to spatially visualize research results and visually display the territorial features of agricultural development [28].

Among *other specific scientific research methods*, we can mention the latest methods of human-geographical research, which were developed by the specialists of the K. Niemets Department of Human Geography and Regional Studies of V.N. Karazin Kharkiv National University. We are talking about such methods as:

- *analysis of the dynamics of system indicators* (it characterizes the detection of time trends in changes in such parameters of the set of social and geographical systems as the progress coefficient, the sum of indices, information entropy, specificity, uniformity of development, the area of projection of the state of the social and geographical system in multidimensional space onto a plane, etc. The results of the analysis are used for adjusting management, long-term planning of agricultural development, etc.);

- *modeling the trajectory of human-geographical system development in multidimensional phase space* (determination of linear and angular parameters of the trajectory at each monitoring phase, assessment of progress or regression in development and the magnitude of its deviation from the optimal trajectory, construction of the trajectory on the phase plane in the coordinates “projection onto the optimal trajectory – deviation from the optimal trajectory”, etc.);

- *component analysis of the development vector* involves assessing the dynamics of administrative-territorial units, regions, or countries based on a set of indicators, where changes in these indicators are recorded using a time derivative with values of “-1”, “0”, and “+1”. The sum of the time derivative codes is used to rank and classify administrative-territorial units/regions/countries with predominantly increasing or decreasing development trends. The above-mentioned research methods are described in more detail in [15].

Among other methods, we can also mention the neural network method, which is based on the use of machine learning technology. This method is used to predict the main indicators of agricultural development with the use of both linear and nonlinear functions. The method allows developing different variants of forecasts [13]. The EU Nature Restoration Regulation identifies three indicators characterizing biodiversity for agricultural ecosystems. These indicators are: the grassland butterfly index (the indicator consists of species typical for European meadows and occur in a large part of the European territory covered by most butterfly monitoring programs), stock of organic carbon in cropland mineral soils (the indicator describes the organic carbon stock in mineral soils of agricultural land at a depth of 0 to 30 cm), share of agricultural land with high-diversity landscape features (this refers to natural or semi-natural components of the agricultural landscape (buffer strips, hedges, trees, water bodies, coastal strips that support biodiversity and provide ecosystem services; these landscapes should not be used for intensive farming and should not be treated with fertilizers/pesticides), the common farmland bird index (the indicator reflects changes in the abundance of typical farmland bird species). The methodology for calculating the indices is presented in more detail in Annexes IV and V to the Regulation [39]. This methodology can be used in further research. The importance of the issues specified in the Regulations requires special studies of a regional nature, including from the perspective of human geography, highlighting local and regional social and geographical systems as objects of research.

**Conclusions.** Therefore, the article considers at the theoretical and methodological level the human-geographical features of the study of agriculture as a complex, multi-level social and geographical system. From this point of view, agriculture should be considered not only as a branch of the economy, but as a functional component of the social and geographical system, interacting with natural and social subsystems through flows of matter, energy and information.

The authors substantiated the structure of agriculture and revealed its multifunctional nature. It is determined that agriculture performs food, raw material, economic, social, environmental, territorial, mentality-forming, culturological, informative functions, which together determine its key role in ensuring the sustainable development of territories and food security. In this aspect, the EU Regulation is important, as it establishes legal mechanisms for the restoration of agricultural lands, contributes to the preservation of the biodiversity of agricultural ecosystems, and increases the resilience of soils and landscapes. The implementation of the pro-

visions of this regulation strengthens the restorative function, which in turn creates the necessary conditions for fulfilling the aforementioned functions of agriculture and helps reconcile social, economic, and environmental interests within the "human-nature" system while also establishing the institutional framework for transitioning agriculture to sustainable and nature-oriented development models.

Scientists have deepened the methodological foundations of human-geographical research on agriculture by combining geographical, systemic, synergistic, informational, and historical approaches. Such integration allows for a comprehensive analysis of the spatial organ-

ization of agriculture, identifying patterns of its development, ways of adaptation, possibilities for the restoration of agricultural systems, and the nonlinear nature of transformation processes in the spatio-temporal dimension.

Therefore, human-geographical research of agriculture based on its comprehensive nature and interdisciplinarity creates a scientific basis for a deeper understanding of spatial differences in its development and can be used to substantiate management decisions, regional development strategies, restoration of agricultural ecosystems, and formation of sustainable agricultural development policies.

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#### **Павло Кобилін**

к. геогр. н., доцент кафедри соціально-економічної географії і регіонознавства імені Костянтина Немця, Харківський національний університет імені В.Н. Каразіна, майдан Свободи, 4, м. Харків, 61022, Україна  
e-mail: [pavlo.kobylin@karazin.ua](mailto:pavlo.kobylin@karazin.ua), <https://orcid.org/0000-0001-9718-5838>

#### **Людмила Немець**

д. геогр. н., професор кафедри соціально-економічної географії і регіонознавства імені Костянтина Немця, Харківський національний університет імені В.Н. Каразіна, майдан Свободи, 4, Харків, 61022, Україна  
e-mail: [ludmila.nemets@karazin.ua](mailto:ludmila.nemets@karazin.ua), <https://orcid.org/0000-0001-9943-384X>

### **СУСПІЛЬНО-ГЕОГРАФІЧНІ ОСОБЛИВОСТІ ДОСЛІДЖЕНЬ СІЛЬСЬКОГО ГОСПОДАРСТВА В АСПЕКТІ РЕГЛАМЕНТУ ЄС ПРО ВІДНОВЛЕННЯ ПРИРОДИ**

У статті пропонується теоретичне та методологічне узагальнення суспільно-географічних особливостей дослідження сільського господарства як складної багаторівневої соціогеосистеми. Важливість цього дослідження впливає зі зростаючої ролі сільського господарства у забезпеченні продовольчої безпеки, сприянні економічному розвитку територій, відновленні природного середовища та сільськогосподарських екосистем, а також необхідності повного розуміння того, як сільське господарство змінюється внаслідок глобалізації, зміни клімату та нерівномірного розвитку регіонів, як того вимагає суспільна географія.

Метою статті є теоретичне обґрунтування та узагальнення суспільно-географічних особливостей сільськогосподарсь-

ких досліджень в аспекті Регламенту ЄС про відновлення природи; визначення його структури та функціонування як відкритої багаторівневої соціогеосистеми; а також визначення методологічних підходів та методів проведення суспільно-географічних досліджень у сільському господарстві.

У статті розкриваються основні теорії розвитку та розміщення сільського господарства, розкрито основні положення Регламенту ЄС про відновлення природи. Автори трактують сільське господарство як ключовий елемент взаємодії соціальних, природних та господарських підсистем, які функціонують у єдності географічного простору та часу. Проаналізовано структуру сільського господарства з виділенням рослинництва та тваринництва, виділено функції сільського господарства: продовольчу, сировинну, економічну, соціальну, екологічну, територіальну, менталітето-формуючу, культурологічну, інформаційну, відновлювальну.

Автори розкривають основні методологічні підходи у дослідженні сільського господарства – географічного, системного, синергетичного, інформаційного та історичного – та обґрунтовують необхідність їх комплексного застосування для постійного аналізу організації сільського господарства у різних регіонах, країнах, виявлення його специфічних особливостей та закономірностей розвитку. Охарактеризовано філософські, загальнонаукові та конкретно-наукові методи суспільно-географічних досліджень сільського господарства

Отримані результати характеризують теоретичну та методологічну основу для суспільно-географічних досліджень сільського господарства на різних ієрархічних рівнях, при розробці стратегій територіального розвитку, відновлення сільськогосподарських екосистем, управління розвитком сільського господарства.

**Ключові слова:** сільське господарство, суспільна географія, соціогеосистеми, методологічні підходи, методи дослідження, функції сільського господарства, Регламент ЄС про відновлення природи.

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**Конфлікт інтересів:** автори засвідчують, що, незважаючи на те, що один із авторів статті є головним редактором, процес рецензування, прийняття рішення щодо публікації та редагування проводилися незалежно, без його участі чи впливу. Рецензування, остаточне рішення ухвалювалося іншими членами редакційної колегії, які не є співавторами. Будь-які потенційні конфлікти інтересів були повністю усунені шляхом зовнішнього контролю процесу.

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