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FORMATION OF THE INTELLECTUAL SYSTEMS FOR THE TERRITORIAL DEVELOPMENT OF LAND ADMINISTRATION IN THE COASTAL REGIONS

Andrii BIELIATYNSKYI[1], Wen MINGMING[2], Liu CHANG[3], Kostyantyn MAMONOV[4*], Olena DYMCHENKO[5]

[1]*School of Civil Engineering, North Minzu University, 204 Wenchang Road, 750021 Yinchuan, NingXia, P.R. China*
[2]*Institute of Management, Guangdong Ocean University, 74780 Zhanjiang, Guangdong, China*
[3]*Institute of Electronics and Information Engineering, Guangdong Ocean University, 74780 Zhanjiang, Guangdong, China*
[4]*Department of Land Administration and Geoinformation Systems, O.M. Beketov National University of Urban Economy, 17 Marshal Bazhanov Str., 61002 Kharkiv, Ukraine*
[5]*Department of Entrepreneurship and Business Administration, O.M. Beketov National University of Urban Economy, 17 Marshal Bazhanov Str., 61002 Kharkiv, Ukraine*

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Highlights

- The concept of the territorial development of land administration have been defined.
- It allowed the theoretical and methodological platform to be formulated based on the systematic approach.
- The conceptual diagram has been developed.
- The best practices of the existing approaches have accumulated.
- A set of tools for the implementation of the modern methods and models has been created.
- The assessment of the level of territorial development of land administration in the region revealed its low rates (the value of the integrated indicator at the regional level varies from 1,799 to 1,83).
- The quantitative basis of the intelligent system of the territorial development of land administration has been formed.

Abstract. It is essential to create the quantitative basis for decision taking on increasing the efficiency of land administration in the coastal regions as an important factor of ensuring development at the regional level. The analysis of the existing scientific research showed lack of unity in theoretical and methodological approaches to defining the territorial development of land administration in the coastal regions, which has been characterized as a combination of spatial, urban planning, investment and environmental factors, the interrelation of which results in achieving a new condition of land management compared to the past, accounting for the social, institutional, managerial peculiarities and the level of communication between the stakeholders operating in the field of land administration in the regions.

Keywords: intelligent systems, land administration in coastal regions, territorial development, factors, integral index.

Introduction

Modern transformation processes connected with the increasing number of crisis phenomena, slowing rates of economic growth, negative influences of the COVID-19 pandemic require reconsideration of approaches to evaluating the territorial development of land administration at the regional level. While the territorial development has a multi-aspect character, there is lack of unified approaches to ensuring it. This process is influenced by spatial, urban planning, investment, environmental and other factors. Therefore, in order to justify the areas of the territorial development, it is necessary to form the quantitative basis for decision taking on increasing the efficiency of

*Corresponding author. E-mail: *kostia.mamonov2017@gmail.com*

land administration as an important factor of ensuring development at the regional level. Within this framework, special attention is drawn to the application of the modern methods of detecting the impact of factors and the identification of the areas of the territorial development based on the application of the intelligent systems. This study focuses on the issues of selecting and applying the intelligent systems (IS), formation of the quantitative basis for decision taking to ensure the territorial development, development of areas for increasing the efficiency of land administration in the coastal regions accounting for the influence of factors.

The existing scientific research lacks unified approaches to defining the intelligent systems of the territorial development of land administration in the coastal regions. Namely, the conceptual provisions for reasoning the intelligent systems and the territorial development of land administration are being considered. Scientific studies define the intelligent systems in terms of creating the organizational, technical, information software accounting for the complexity of design defined by the completeness of the a priori information about the IS being developed, necessity to take compromise decisions, inconsistency with the practical requirements, potential risks for ensuring the system's functioning and ensuring the efficiency of its operation (Dovbysh, 2009). When defining the intelligent information systems, some researchers focus on the peculiarities of their formation and functioning:

- the presentation of the studied object's model and its environment as a knowledge base and means of deductive and credible conclusions in a combination with the possibility to process incomplete and inaccurate information;
- the decisions of the intelligent systems are characterized by transparency, i.e. can be explained to the user in the appropriate form;
- the ability to automatically identify certain consistent patterns in previously collected data with their further accumulation in the data base;
- the intelligent information system provides the user with a ready solution, which according to its quality and efficiency is highly competitive with the solutions provided by a human expert (Makarenko, 2009).

Besides, the intelligent information systems are classified according to the following criteria:

- subject matter application (management, risk-management, investment, military intelligent information systems, etc.);
- degree of self-containment (self-contained individual software products with their own data base, completely integrated);
- the way and speed of response (static, dynamic, real time);
- degree of adaptivity (intelligent information systems based on machine learning, i.e. the systems whose parameters and structure change in the process of learning or self-learning, IIS whose parameters are changed by the administrator);
- the model of knowledge provision (nonmonotonic, modal and temporal logics, Markov chain and Bayesian network, casual trees, intelligent information systems based on Dempster-Shafer theory, fuzzy systems, etc.) (Makarenko, 2009).

Unlike in previous approaches, the intelligent information systems are defined in terms of using artificial intelligence in software:

1. Adaptive and self-adaptive systems designed for completing tasks through accounting for a-priori information and the information accumulated in the process of exploitation. These systems are developed based on their operating experience and acquiring this experience is one of the technological stages of creating such systems.

2. Large-scale open systems designed by a significant number of developers, often not even connected with each other. They are not developed in accordance with a specific plan created well in advance, but rather chaotically. The systems of such type create an open source data base which can be contributed to by the developers and accessed by the users irrespectively of their location (Lutsenko, 2004).

The following features of the intelligent information system functioning are identified:

- possibility of accumulation and further application of knowledge about the results of learning to choose the individual educational influence and to control the learning process in order to form knowledge and skills;
- validity of the criteria for assessing the level of knowledge and skills, level of competence, level of material digestion (identification level, level of building algorithms, heuristic, creative levels);
- possibility to adapt the system to the individual mode of learning (Zhelnin et al., 2012).

The advantages of the intelligent information systems, which namely include the possibility of cross-reference have been detected (Suslova, 2008). A major area of intelligent information system development is creation and development of intelligent multi-agent systems. The agent is defined as a self-sufficient artificial object (computer software or module) that demonstrates active and motivated behavior and is capable of interacting with other objects in the dynamic virtual environments with the purpose of arranging, analyzing and maintaining the users' profiles, providing users and other agents with necessary information for knowledge and navigation (Sharov, 2015).

Typical of intelligent agents are the following features and characteristics:

- self-sufficiency (ability to operate without any interference on behalf of its owner, to control its own activities and internal condition);
- proactive attitude (ability to arrange and implement its activities);
- possibility to interact and communicate with other agents;
- reactivity (adequate perception of the environment and relevant response to its changes);

- purposefulness (availability of its own sources of motivation);
- availability of basic knowledge about itself, other agents and the environment;
- persuasion (part of the basic knowledge can be changed in time);
- wishes (aspiration for specific conditions);
- intentions (actions planned by the agent for completing its tasks and fulfilling its wishes);
- commitments (tasks completed by one agent at the instructions of other agents) (Gromov et al., 2013).

The functional peculiarities of intelligent systems application are focused in the works of Zhelnin et al. (2012), Izbachkov et al. (2005), Streltsov (2010). The intelligent systems are aimed at creating and implementing modern technological tools through developing advisory expert intelligent search and logical systems applying C # /. Net, C++, Java, HTML/CSS, JavaScript, Assembler (Intellective systems and technologies, 2021). The retrospective issues of the Artificial Intelligence (AI) development as a major area of intelligent system development are highlighted in the works of Karpenko (2011), Matviychuk (2011), Newell (1980), Artificial intelligence: history and prospects (2017). The AI is considered as a system that can deal with knowledge and learn; possibility and specific way of studying problems; a range of algorithms and software systems that can substitute a human being and create a basis for decision taking (Luger, 2004); is designed for completing one task or a set of specific tasks and allows machines, devices, programs, systems and services to function in terms of understanding this task and situation (World Economic Forum, 2016). It is worth mentioning that experts believe that application of the intelligent systems allows to ensure the increase of gross added value in the following areas: education – 1.6 times; other services – 1.7 times; public services – 2.3 times; social services – 2.8 times; leisure and entertainment – 3.1 times; utilities – 3.1 times; hospitality business – 3.2 times; agriculture, fishery – 3.4 times; construction – 3.4 times; healthcare – 3.4 times; professional services – 3.8 times; logistics – 4 times; wholesaling and retailing – 4 times; financial services– 4.3 times; industry – 4.4 times; information and telecommunications – 4.8 times (Radiosvoboda, 2019).

The areas of AI application and its advantages are highlighted in the work "AI: key areas and prospects for application" (2018) and Raghavan (2008). Thus, intelligent systems are defined as a modern complex set of tools based on the application of the artificial intelligence, with the implementation of technological means of developing expert, advisory, intelligent information search, logical calculation systems based on the information background and aimed at solving problems, defining algorithms, program systems that can replace a human being and create a basis for decision taking. The concept of the territorial development of land administration at the regional level is based on the theoretical and methodological provisions developed within the following studies: Yeroshkina (2009), Mamonov (2018a, 2018b, 2019a, 2020a), Kravtsiv (2015). The research showed discrepancies in the theoretical and methodological approaches to defining the territorial development of land administration in the regions and offered it major characteristic as a combination of spatial, urban planning, investment and environmental factors, the interrelation of which results in achieving a new stance of the land administration quality compared to the past, taking into account social, institutional, managerial peculiarities and the degree of the stakeholders' involvement in the area of the land administration in the regions (Mamonov, 2019b; Mamonov et al., 2020b).

1. Materials and methods

Based on the theoretical and methodological approaches and the unsolved problems of ensuring the territorial development of land administration in the regions, the aim of the research was formulated as follows: to create a quantitative basis for decision taking aimed at ensuring the territorial development of land administration based on the application of the intelligent systems.

The achievement of the set aim requires solving the following tasks:

- evaluation of the level of the territorial development of land administration;
- identification of factors influencing the territorial development of land administration at the regional level;
- establishing the cause-and-effect relationships in the factors' impact on the level of the territorial development of land administration with the application of the intelligent systems.

The evaluation of the territorial development of land administration in the regions is carried out according to the proposed integral method (Mamonov, 2019b; Mamonov et al., 2020b). The territorial development of land administration in the regions under the conditions of the worldwide crisis is influenced by the COVID-19 pandemic. The problems of unbalanced development have been detected, which resulted in emergence of the following factors: economic, geopolitical, social, psychological, etc. At the same time, the major focus is on the statistical data showing the number of COVID-19 cases, deaths and recoveries as of April 09, 2021 in the regions of Ukraine (Table 1).

Since the absolute rates represent a lesser level data credibility in some regions, the relative rates per capita have been calculated and then ranked in Table 2:

$$p'_{ij} = \frac{p_{ij}}{POP_j}, \quad (1)$$

where p_{ij} – absolute value of the i-th index in the j-th region, POP_j – population of the j-th region.

It can be seen that the most critical situation was observed in the City of Kyiv, Ivano-Frankivsk, Sumy, Zhytomyr and Chernihiv Regions. The regions of Ukraine differ greatly in terms of the covered area and the density of population. It has been an axiom statement that there is a direct relationship between the virus contagion rate, number of contacts and the density of the population.

Table 1. Statistical data on Coronavirus contagion in the regions of Ukraine as of April 09, 2021

Regions	Total			Per capita in the region			Density of population
	Cases	Deaths	Recoveries	Cases	Deaths	Recoveries	
Vinnytsia Region	61.619	1.229	39.235	0.0403	0.0008	0.0403	57.67
Volyn Region	49.816	828	42.125	0.0485	0.0008	0.0485	50.99
Dnipro Region	99.373	2.556	78.669	0.0317	0.0008	0.0317	98.33
Donetsk Region	64.402	1.393	50.672	0.0157	0.0003	0.0157	154.53
Zhytomyr Region	76.286	1.326	55.445	0.0639	0.0011	0.0639	40.04
Transcarpathian Region	56.975	1.401	44.385	0.0456	0.0011	0.0456	97.99
Zaporizhzhia Region	83.383	1.529	70.206	0.0501	0.0009	0.0501	61.23
Ivano-Frankivsk Region	81.309	1.814	67.682	0.0598	0.0013	0.0598	97.67
Kyiv Region	103.187	1.806	81.722	0.0577	0.0010	0.0577	63.59
Kropyvnytskyi Region	14.375	502	9.461	0.0156	0.0005	0.0156	37.37
Luhansk Region	18.936	571	15.631	0.0089	0.0003	0.0089	79.45
Lviv Region	113.448	2.782	83.462	0.0455	0.0011	0.0455	114.33
Mykolayiv Region	54.985	1.223	43.329	0.0497	0.0011	0.0497	45.03
Odesa Region	117.579	2.028	85.422	0.0497	0.0009	0.0497	71.04
Poltava Region	59.673	1.262	49.536	0.0436	0.0009	0.0436	47.66
Rivne Region	62.198	815	53.034	0.0542	0.0007	0.0542	57.25
Sumy Region	63.118	892	52.217	0.0600	0.0008	0.0600	44.15
Ternopil Region	59.026	884	47.654	0.0573	0.0009	0.0573	74.50
Kharkiv Region	113.253	2.130	89.394	0.0430	0.0008	0.0430	83.75
Kherson Region	26.263	736	21.830	0.0259	0.0007	0.0259	35.68
Khmelnytskyi Region	71.338	1.300	54.725	0.0574	0.0010	0.0574	60.24
Cherkasy Region	62.682	811	51.572	0.0533	0.0007	0.0533	56.27
Chernivtsi Region	72.795	1.469	51.732	0.0812	0.0016	0.0812	110.71
Chernihiv Region	45.606	926	35.294	0.0468	0.0009	0.0468	30.57
City of Kyiv	172.403	3.749	109.449	0.0582	0.0013	0.0582	3540.98

Table 2. Ranking of the statistical data on Coronavirus contagion in the regions of Ukraine as of April 09, 2021

Region	Cases	Deaths	Recoveries	Density of population
Vinnytsia Region	20	19	20	15
Volyn Region	14	18	14	18
Dnipro Region	21	16	21	5
Donetsk Region	23	24	23	2
Zhytomyr Region	2	6	2	22
Transcarpathian Region	16	4	16	6
Zaporizhzhia Region	11	12	11	13
Ivano-Frankivsk Region	4	2	4	7
Kyiv Region	6	9	6	12
Kropyvnytskyi Region	24	23	24	23
Luhansk Region	25	25	25	9
Lviv Region	17	5	17	3
Mykolayiv Region	13	7	13	20
Odesa Region	12	14	12	11
Poltava Region	18	11	18	19
Rivne Region	9	21	9	16
Sumy Region	3	15	3	21
Ternopil Region	8	13	8	10
Kharkiv Region	19	17	19	8
Kherson Region	22	20	22	24
Khmelnytskyi Region	7	8	7	14
Cherkasy Region	10	22	10	17
Chernivtsi Region	1	1	1	4
Chernihiv Region	15	10	15	25
City of Kyiv	5	3	5	1

End of Table 2

The correlation analysis aimed at identifying how close the connection between the statistics on Coronavirus contagion and the density of the population in the regions is (the correlation coefficient has been calculated according to the formula:

$$r_{xy} = \frac{\sum_i (x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \times (y_i - \bar{y})^2}}, \quad (2)$$

where $\bar{x}, \bar{y}$ – average values of the corresponding indices confirm a moderate connection with the number of cases $(r_{xy} = 0.65)$ and a high connection with the number of deaths $(r_{xy} = 0.71)$.

The correlation analysis, however, cannot identify the deep reasons of the problems. For example, although the regions on top of the rank in terms of Coronavirus contagion – the City of Kyiv and Chernihiv Regions – are in fact the most highly populated ones (the 1st and the 4th positions among 25 regions of Ukraine), at the same time, Sumy and Zhytomyr Regions are the less populated regions of Ukraine (the 21st and the 22nd positions, correspondingly). High density of population in the City of Kyiv is explained by the rates of domestic migration, which is caused by decreasing number of actively operating enterprises. The outflow of the working population from the regions is both the cause and the result of the deteriorating social conditions. The level of the average monthly salary (as of 2019) in Zhytomyr Region is 405% of the subsistence rate, while in the City of Kyiv it is 750%. Table 3 shows the indicators of the number of healthcare facilities available in the regions, the number of operating enterprises. Their comparison clearly demonstrates lack of balance in the regions' development.

The factors influencing the territorial development of land administration have been identified. Thus, the information and analytical provision has been formed to carry out the research on creating the quantitative basis for decision taking aimed at ensuring the territorial development of land administration based on the application of the intelligent systems accounting for the influence of factors at the regional level. The method of integral evaluation of the territorial development of land administration in the regions has been proposed, which consists of the following stages: Carrying out the geofactor analysis to create a complex of spatial, urban planning, investment and environmental factors influencing the territorial development of land administration in the region based on the existing scientific and methodological studies and legal norms and regulations: $F = \langle F_1, F_2, F_3, F_4 \rangle$; creating a multilevel system of factors: $M = \langle F_1, F_2, F_3, F_4 \rangle$, $\Omega = \{\varpi_p\}$, $p = \overline{1, \psi}$; selection of factors having the greatest impact on the territorial development of land administration in the region through the Delphi method according to the set criteria.

Table 3. Indicators of the healthcare capacities available in the regions, the number of operating enterprises

Region	Number of healthcare facilities	Number of beds per 10,000 inhabitants	Number of doctors per 10,000 inhabitants	Number of nursing personnel per 10,000 inhabitants	Number of enterprises	Capital investment into environment protection
Vinnytsia Region	62	69	49.1	97.3	70.293	59 287.6
Volyn Region	46	70.1	38.3	100.1	41.138	36 064.8
Dnipro Region	142	87.5	47.2	87.1	31.191	2 564 144
Donetsk Region						
Zhytomyr Region	44	68.6	37.9	103.1	51.002	6864.9
Transcarpathian Region	47	67.8	38.8	82.5	50.608	14 051.2
Zaporizhzhia Region	79	83.6	49.1	90.2	15.652	1 083 530.8
Ivano-Frankivsk Region	77	76.7	61.3	105.7	8.595	248 495
Kyiv Region	73	72.5	41.7	83.9	21.077	6 945 708.4
Kropyvnytskyi Region	51	85	35.4	95.2	36.447	14 179.4
Luhansk Region						
Lviv Region	124	83	55.5	101.2	20.480	221 270.4
Mykolayiv Region	46	70.6	33.9	75.9	12.278	214 167.6
Odesa Region	88	77.9	47.1	83.5	25.871	67 439.5
Poltava Region	69	79	49	96	64.686	295 281.4
Rivne Region	50	73.8	41.5	104.4	41.741	36 207.1
Sumy Region	55	82	40.8	104.2	41.675	23 393.4
Ternopil Region	63	83.2	52.7	102.9	37.821	25 348.8
Kharkiv Region	123	83.7	57.9	87	162.794	472 800
Kherson Region	40	76.6	36	84.7	45.996	7357.7
Khmelnytskyi Region	57	78.8	43.9	99.5	63.402	70 875.9
Cherkasy Region	54	80.7	38.6	97.2	56.493	33 085.9
Chernivtsi Region	41	73.2	60.1	98.7	4.235	30 112.9
Chernihiv Region	50	93.3	37	104.2	41.242	49 732.4
City of Kyiv	121	102	85	111	294.458	1 156 035

1. Forming a multilevel system of indices through the application of quasimetric models of transition from the proposed factors to the corresponding spatial, urban planning, investment and environmental indices considering the assessment ratio values: $M = \langle T_1, T_2, T_3, T_4 \rangle$, $\Omega = \{\varpi_p\}$, $p = \overline{1,\psi}$.
2. Evaluating the system of spatial, urban planning, investment and environmental indices of level 3 based on the analytical and Delphi methods: $t_{11i}, t_{21i}, t_{31i}, t_{41i}$.
3. Identifying spatial, urban planning, investment and environmental indices of level 2 via creating mathematical models based on the method of average geometric magnitude evaluation:

$$t_{1i} = \sqrt[n]{\prod_{l=0}^{L} t_{1ij}}; \quad (3)$$

$$t_{2i} = \sqrt[n]{\prod_{l=0}^{L} t_{2ij}}; \quad (4)$$

$$t_{3i} = \sqrt[n]{\prod_{l=0}^{L} t_{3ij}}; \quad (5)$$

$$t_{4i} = \sqrt[n]{\prod_{l=0}^{L} t_{4ij}}. \quad (6)$$

4. Creating a mathematical model of identifying integral spatial, urban planning, investment and environmental indices of the territorial development of land administration in the region:

$$T_1 = t_{1i} \times k_{vt1i}; \quad (7)$$

$$T_2 = t_{2i} \times k_{vt2i}; \quad (8)$$

$$T_3 = t_{3i} \times k_{vt3i}; \quad (9)$$

$$T_4 = t_{4i} \times k_{vt4i}. \quad (10)$$

5. Identifying weighting factors characterizing the significance of spatial, urban planning, investment and environmental indices in the system of the territorial development of land administration in the regions based on the analytic hierarchy process: k_{vt1i}, k_{vt2i}, k_{vt3i}, k_{vt4i}.
6. Identifying integral spatial, urban planning, investment and environmental indices of territorial development of land administration in the region: T_1, T_2, T_3, T_4.
7. Evaluating the integral index of the land management in the regions:

$$T = \sqrt[4]{T_1 \times T_2 \times T_3 \times T_4}. \quad (11)$$

8. Developing and demonstrating the feasibility of the level scale of the territorial development of land administration.
9. Interpretation of the obtained results (Mamonov et al., 2020b).

The results of calculating the integral index of the level of territorial development of land administration in the regions are presented in Figure 1.

Based on this evaluation, the level of the territorial development of land administration has been identified as low. The highest rates were observed in Poltava, Chernihiv, Vinnytsia and Ivano-Frankivsk Regions, while the lowest rates were in Odesa and Sumy Regions.

2. Results

Based on the identified connections, the intelligent data analysis is carried out in the following areas:

– formation of the subject matter expert groups on land management, economy, social care, education, security, etc. with the purpose of identifying a group of factors having the greatest impact on the territorial development:

$$G = \sum_{n=1}^{N} G_n, \quad (12)$$

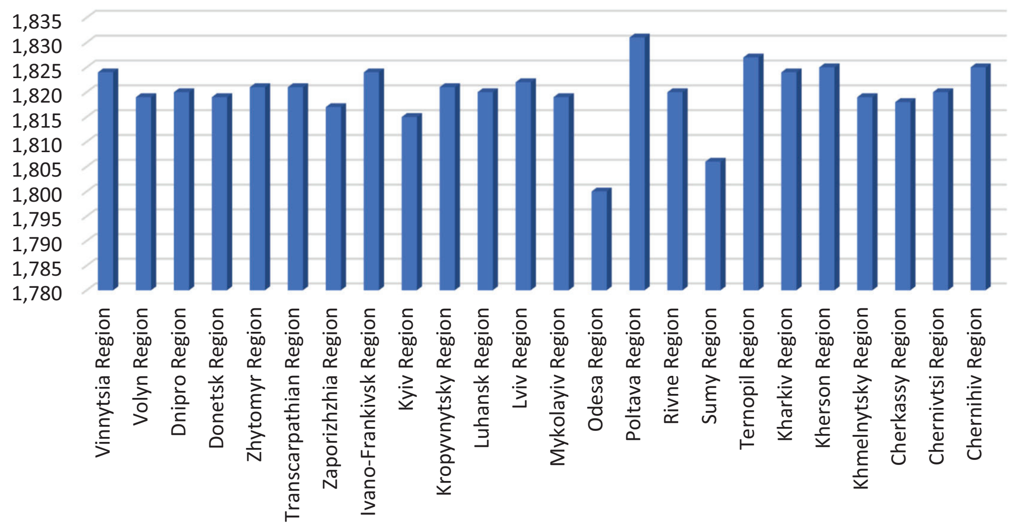

Figure 1. Integral indices of the level of territorial development of land administration in the regions, per unit value

where G is aggregate of expert groups G_n, n is group number.

Simultaneously, the formation of the group of active inhabitants of the region is recommended, who are not qualified to be experts in terms of their specialization or professional experience, but have an active civil position and outlook of the territory's perspective development as average citizens.

– based on the expert evaluation, the factors having the greatest impact on the territorial development are identified by each group of subject matter experts:

$$F^{G_n} = \left\{ f_1^{G_n}, f_2^{G_n}, \ldots, f_k^{G_n} \right\}, \quad (13)$$

where F^{G_n} is a combination of factors $f_k^{G_n}$ of the G_n-th group.

The set of factors is arranged in tuples, where the lowest sequence number refers to the factor with the greatest impact:

$$F^{G_n} = f_{(1)}^{G_n}, f_{(2)}^{G_n}, \ldots, f_{(k)}^{G_n}, \quad (14)$$

where (1), (2), …, (k) is factor rank number.

Special attention should be drawn to the factors identified by several groups of experts:

$$F^{G_i} \cap F^{G_j} = \left\{ \ddot{f}_1^{G_{ij}}, \ddot{f}_2^{G_{ij}}, \ldots, \ddot{f}_p^{G_{ij}} \right\}, \quad (15)$$

where $\ddot{f}_p^{G_{ij}}$ – factors selected simultaneously by expert groups F^{G_i} and F^{G_j}.

– the mechanisms of collecting statistical data necessary to evaluate the factors of influence are arranged according to the sources and methods: those acquired from the State Department of Statistics in the regions and those acquired as a result of the field study, i.e. collecting the raw data directly for solving the assigned problem. In order to collect raw data through the methods of observation or experiment, it is necessary to form groups of experts, detect the control objects for the research, as well as their number, so that credible representative data can be obtained in each region, as well as to identify quantitative characteristics and the measurement methods.

– tracing the functional relationship of each of the factors $f_k^{G_n}\left(t_1, t_2, \ldots, t_p\right)$ and the time, number of the control objects, their location allows to determine the direction of the changes in the system factor depending on the impact of local factors through the methods of differential measurements:

$$\frac{\partial f_k^{G_n}}{\partial t_i} = \lim_{\Delta t_i \to 0} \frac{f_k^{G_n}\left(t_1, \ldots, t_i + \Delta t_i, \ldots, t_p\right) - f_k^{G_n}\left(t_1, \ldots, t_i, \ldots, t_p\right)}{\Delta t_i}, \quad (16)$$

where t_i $\left(i = \overline{1, p}\right)$ is a function argument, find the extremums of the functions, make a prediction and a model-based imitation with the purpose of detecting the influence of the factors with the in advance foreseen characteristics on the final result:

$$f_k^{G_n}\left(t_1, t_2, \ldots, t_p\right) \to \dot{f}_k^{G_n}\left(\dot{t}_1, t_2, \ldots, t_p\right) \to \ddot{f}_k^{G_n}\left(t_1, \dot{t}_2, \ldots, t_p\right) \to \ldots \dddot{f}_k^{G_n}\left(t_1, t_2, \ldots, \dot{t}_p\right), \quad (17)$$

where $\dot{f}_k^{G_n}$ is a model-based imitation when changing a parameter $\dot{t}_1$ and so on.

– in order to compare the degree of influence of each of the factors, their measurement units should be the same. Since the selected factors have been defined on different sets when solving the assigned task, it is necessary to standardize all the factors in each group:

$$\widetilde{f}_k^{G_n} = \frac{f_k^{G_n}}{\left|f_k^{G_n}\right|}, \quad (18)$$

where $\left|f_k^{G_n}\right|$ – the highest, the lowest or an average value of the factor (as chosen by the expert group).

– in order to study the dependency between the criterion variable and the predictor variables, the regressive analysis should be carried out. Among a great variety of methods for building the linear regression model, the most time saving is the exception method, according to which the primary regressive equation is calculated, which has all the factors selected for building the model-based imitation:

$$\Phi^{G_n} = a_0 + a_1 f_1^{G_n} + a_2 f_2^{G_n} + \ldots + a_p f_p^{G_n} + \varepsilon, \quad (19)$$

where $a_0, a_1, \ldots, a_p$ is regressive equation coefficients.

At the next stage, the value of the partial F-criterion is calculated for each of p-factors. Those factors, whose values of F-criterion turn out to be lower than the one predicted in advance, are excluded from the regression model. Partial F-criterion is based on comparing the increase of the factor variance, which is caused by inclusion of the extra factor with the residual variance and is calculated according to the formula:

$$F_{f_j^{G_n}} = \frac{R^2_{\Phi^{G_n} f_1^{G_n} f_2^{G_n} \ldots f_j^{G_n} \ldots f_p^{G_n}} - R^2_{\Phi^{G_n} f_1^{G_n} f_2^{G_n} \ldots f_{j-1}^{G_n} \ldots f_p^{G_n}}}{1 - R^2_{\Phi^{G_n} f_1^{G_n} f_2^{G_n} \ldots f_j^{G_n} \ldots f_p^{G_n}}} \times (n - p - 1), \quad (20)$$

where n is a number of observations, p is a number of parameters in a model.

– the intelligent system of territorial development should be created through the integral methods accounting for the degree of significance of each group of factors' impact represented in the form of the normalizing coefficient, the value of which is calculated based on the numerical experiment:

$$\Omega = \sum_{t=1}^{N} M_t \times F^{G_t}, \quad (21)$$

where M_t is normalizing coefficients.

Based on the proposed areas and directions, the algorithm of forming the system of evaluating the factors' influence on the level of territorial development has been built (Figure 2).

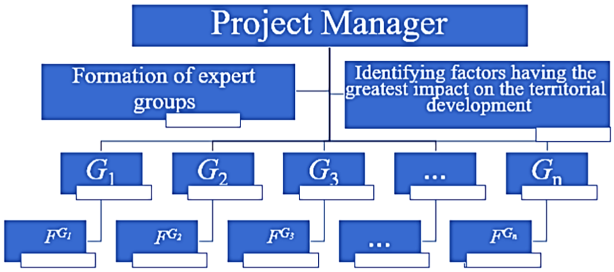

Figure 2. Algorithm of creating the system for evaluating the degree of the factors' influence on the territorial development

Conclusions

The research resulted in defining the notion of the territorial development of land administration in the region, the typical feature of which is accounting for the directions of changes in spatial, urban planning, investment and environmental factors, which allowed to formulate the theoretical and methodological platform based on the systematic approach, to develop the conceptual diagram and identify the dominating areas for solving the issue of increasing the efficiency of land administration for the territorial development of the regions, to identify problematic elements in the field of land administration, to accumulate the best practices of the existing approaches and create a complex set of tools for the implementation of the modern methods and models. The areas of conducting the intelligent analysis for identifying the level of the territorial development of land administration in the regions have been proposed, which allowed for the creation of an algorithm of evaluating the degree of the factors' influence on the territorial development, which is universally applicable due to the possibility to choose from a variety of factors of influence in combination with their number and the scale of the research objects. Based on the developed algorithm and the created system of evaluating the level of territorial development, the quantitative basis of the intelligent system of the territorial development of land administration is formed.

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References

Dovbysh, A. S. (2009). *Fundamentals of designing intelligent systems*. https://essuir.sumdu.edu.ua/handle/123456789/1407

EDU Blog. (2017). *Artificial intelligence: History and prospects*. https://edublog.com.ua/blog/id1306053891/posts/moi-publikatsii/istoriya-rozvytku-shtuchnoho-intelektu

Everest-AI-Review. (2018). *AI: Key areas and prospects for application*. https://www.everest.ua/ai-platform/analytics/ai-klyuchovi-sferi-ta-perspektivi-zastosu/

Gromov, Yu., Ivanova, O., Alekseev, V., Belyaev, M., Shvets, D., & Eliseev, A. (2013). *Intelligent information systems and technologies*. FGBOU VPO "TSTU".

Intellective systems and technologies. (2021). https://khai.edu/ua/specialties/kompyuterni-nauki/41/

Izbachkov, Yu., Petrov, V., Vasiliev, A., & Telina, I. (2005). *Information systems: A textbook for universities*. https://drive.google.com/file/d/1so4eKtVaL_t9skcBw98iEjO319g3zu1L/view

Karpenko, V. (2011). Hypothetical future of universal artificial intelligence. *Philosophy of Science: Traditions and Innovations*, *1*(3), 57–64.

Kravtsiv, V. (2015). *Territorial development and regional policy in Ukraine: Challenges and priorities of Ukraine*. State Institution Institute of Regional Research named after M.I. Dolishniy of NAS of Ukraine. http://ird.gov.ua/irdp/p20180701.pdf

Luger, G. (2004). *Artificial intelligence: Strategies and methods for solving complex problems*. Williams Publishing House.

Lutsenko, E. (2004). *Intelligent information systems*. KubGAU.

Makarenko, S. (2009). *Intelligent information systems*. https://zzapomni.com/mggu-im-sholohova-moskva/makarenko-intellektualnye-informac-2009-5875/view

Mamonov, K. (2018b). Theoretical approaches to determining the territorial development of land use in the region. *Technical Sciences: V. Vernadsky Tavriya National University*, *68*(6), 212–216.

Mamonov, K. (2018a). International experience in ensuring the territorial development of land use in the region. *Municipal Economy*, *146*, 225–231. https://doi.org/10.33042/2522-1809-2018-7-146-225-231

Mamonov, K. (2019a). Methodological approach to the integral assessment of the regional lands use territorial development. *Geodesy and Cartography*, *45*(3), 110–115. https://doi.org/10.3846/gac.2019.8555

Mamonov, K. (2019b). *Territorial development of land use in the region: definition, evaluation and directions of transformations*. FOP Panov AM.

Mamonov, K. (2020a). *Territorial development of land use in the region: directions and features of evaluation*. O.M. Beketov National University of Urban Economy.

Mamonov, K., Wen, M., & Kondratyuk, I. (2020b). Formation of investment inactiveness of the territories: experience of coastal regions of China. *Priazovsky Economic Bulletin*, *2*(19), 171–176.

Matviychuk, A. (2011). Possibilities and prospects of creating artificial intelligence. *Bulletin of the NAS of Ukraine*, *12*, 36–51.

Newell, A. (1980). Physical symbol system. *Cognitive Science*, *4*, 135–183. https://doi.org/10.1207/s15516709cog0402_2

Radiosvoboda. (2019). *Life in another dimension: Artificial intelligence and its impact on humanity.* https://www.radiosvoboda.org/a/shtuchnyi-intelekt-zagrozy-i-mozhlyvisti/31145992.html

Raghavan, N. (2018). *How AI is driving digital transformation*. https://www.linkedin.com/pulse/how-ai-driving-digital-transformation-narasimhan-s-raghavan

Sharov, S. (2015). The current state of development of intelligent information systems. *Actual Problems of Higher Pedagogical Education*, *130*. http://www.irbis-nbuv.gov.ua/cgi-bin/irbis_nbuv/cgiirbis_64.exe?C21COM=2&I21DBN=UJRN&P21DBN=UJRN&IMAGE_FILE_DOWNLOAD=1&Image_file_name=PDF/VchdpuP_2015_130_26.pdf

Streltsov, R. (2010). *Artificial intelligence in education*. DonNTU.

Suslova, I. A. (2008). *Methods of teaching students of computer specializations using intelligent information systems*. Russian State Vocational Pedagogical University.

World Economic Forum. (2016). *Our shared digital future responsible digital transformation – Board briefing*. http://www3.weforum.org/docs/WEF_Responsible_Digital_Transformation.pdf

Yeroshkina, O. (2009). *Territorial natural and economic differences as an objective basis for the territorial division of labor and regional development*. http://nbuv.gov.ua/j-pdf/DeBu_2009_2_2.pdf

Zhelnin, M. E., Kudinov, V. A., & Belous, E. S. (2012). The role and place of expert systems in education. *Scientific Notes: Electronic Scientific Journal of Kursk State University, 2*(22). https://cyberleninka.ru/article/n/rol-i-mesto-ekspertnyh-sistem-v-obrazovanii