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Economic Assessment of the Relationship Between Housing and Communal Infrastructure Development Factors and Population Quality of Life in Ukraine

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ABSTRACT

Improving the quality of life of the population is one of the strategically important directions of modernisation of Ukrainian society. The research focuses on identifying and justifying the interconnection and interdependence of the quality of life of the population and the factors of development of housing and communal infrastructure. The purpose of the given paper is to economic assessment of the relationship between factors of development of housing and communal infrastructure and the quality of life of the population of Ukraine. The object of present research is of the quality of life of the population and the factors of development of housing and communal infrastructure. The hypothesis of the study is that official statistical data do not provide a comprehensive description of the relationship between housing infrastructure development and improvements and the quality of life. A multivariate statistical analysis of the correlation between the level of development of the housing and communal infrastructure and the quality of life of the population made it possible to establish general patterns characterizing the interdependence of interrelated variables and to establish a close relationship between them. The main tools used for a multidimensional statistical analysis and forecasting are the BCG matrix; map of correlations; least squares method, scatterplot, taxonomic analysis method, Durbin-Watson autocorrelation test, cluster analysis; schematic map of the results of clustering, foresight methods and Holt's method of linear exponential smoothing. The research has shown a linear relationship between the component of the quality of life of the Ukrainian population and the development level of housing and communal infrastructure, in particular, the improvement of housing stock of Ukraine. The three-dimensional model of integrated assessment of the state of housing and communal infrastructure allowed the current state of housing and communal infrastructure and determining the conditions for its development. The practical relevance of the study is to develop recommendations to create conditions for balanced development of housing and communal infrastructure of the state.

INTRODUCTION

One of the priorities of modernising society and achieving the Millennium Development Goals is improving the quality of life of the population. It is known that the quality of life of the population is a multidimensional category, dependent on the effect of many objective and subjective factors, including the state of providing the population with decent housing and communal conditions. Crises in the global economy have had a negative impact on the volume of investment in developing countries, thus slowing down mortgage lending systems, development of the housing and utility sector and exacerbating population inequality in access to quality housing. In Ukraine, in addition to the above, the development of the housing and communal structure was also influenced by the processes of a decline of the settlement network due to the armed conflict in Donbass. These regions have suffered partial and sometimes complete destruction of housing stock and strategically important infrastructure. Building housing and communal infrastructure in the country and improving the quality of life of the population should become strategically important elements in national security. This is due to the fact that the stratification of the population by income and the reduction of conditions of equal access to quality housing exacerbated the risks of social exclusion of the population, led to further polarization and marginalization of the population. Improved monitoring of the housing and communal sector and modernisation of its quantitative and qualitative analysis in temporal and spatial dimension will help to solve the identified problems and ensure the effectiveness of management decisions in this direction. Thus, it becomes necessary to create a methodology for assessing the relationship between the components of the development level of the housing and communal structure and the quality of life of the population with consistent forecasting of future changes through the use of economic and mathematical calculations and qualitative determination of factor influences on the dynamics of this infrastructure.

1. LITERATURE REVIEW

The problems of the theory and methodology of investigating the relationship between household income, housing and the quality of life have been in the midst of social research in the last twenty years. Thus, D. Conley (2001), who examined the role of housing in the social stratification system and, after comparing data on income dynamics of two generations, proved that there was an impact of the availability of housing for a family on the size of socio-economic status, race, and quality of life of the next generation. R. Dwyer (2007) argued that housing infrastructure reflects a broader structure of population stratification and it is sufficiently sensitive to a rapid increase in income inequality. Using a variety of statistical sources, including census results, and studying income trends of those, who buy new home, R. Dwyer (2007) found that at the end of the twentieth century, society was increasingly stratified and distinguished by property status. These trends will exacerbate population inequality through the structure of housing-related opportunities, including access to education and accumulation of housing capital. Of significant research in this area, it is also worth mentioning the work of P. Nguyen-Hoang and J. Yinger (2011); M. Besbris and J. Faber (2017); E. Korver-Glenn (2018); A. Owens (2019). Various aspects of studying the impact of the development of housing and communal infrastructure on the quality of life of the population can be traced in scientific papers of a galaxy of domestic scientists. T. Vasyltsiv et al. (2019) have devoted their researches to the problems of housing development and social policy on improving the efficiency of implementing housing programmes in the conditions of limited financial and material resources. In recent years, researches that focus on the study of theoretical and methodological foundations in the relationship between income, housing and quality of life have intensified. S. Poliakova and Y. Kohatko (2017) analyse housing from the perspective of a hierarchy of human needs. The authors argue that the ability to meet the needs of the higher level of the hierarchy is not only dependent on the qualitative characteristics of accommodation, but is also determined to some extent by quantitative parameters. Given that, the problem of housing is now quite acute, especially in low-income countries, the social policy of most countries is aimed at providing as many people with housing as possible. Scientific and analytical studies of V. Novikov (2018) on the functioning and financing of housing and communal services at the interregional and regional levels prove that meeting the needs of the population for housing is not only a basic characteristic of quality of life, but also an important condition for the reproduction of the demographic potential of the country. The author is of the opinion that the creation of a wide network of specialized mortgage banks will help to prevent the growth of property stratification in Ukraine, which will ensure equal access to long-term loans and will help to reduce the risk of issuing mortgage-backed securities. In his work, V. Shishkin (2012) pays considerable attention to the analysis of the provision and quality of housing conditions of different types of households, the adequacy of living space and comfort of housing for different types of households, the determination of the components of unequal opportunities for households with children as to improving living conditions. The research by V. Shishkin (2016) sheds light on the results of integrated estimates of population poverty by housing conditions, on the basis of which the population differentiation by main indicators of housing poverty in terms of place of living and types of household is performed. O. Tyshchenko (2015) devoted his attention to the problematic aspects of estimating quantitative and qualitative indicators of the development of housing and living conditions of the population. Using the methods of comparative analysis, the scientist determined the level of comfort of available housing, investigated the dynamics of new housing construction and suggested directions of correcting the state housing policy in order to increase the level of satisfaction of the population's needs for social housing.

According to the results of the statistical analysis, L. Cherenko (2018) concluded that the population of Ukraine is characterised by a significant stratification by living conditions. The author believes that historically Ukraine has lagged behind developed countries for a long time in housing standards and that is why Ukrainians have misconceptions about satisfactory living conditions. Y. Kohatko (2019), also supports this position noting that according to his research, more than half of households in Ukraine are now deprived of minimum necessary living conditions, with the worst being the situation of providing rooms in accordance with a certain minimum allowed norm EU-SILC minus 1, i.e. one room less than according to European standards, which does not contribute to improving the quality of life of the population. Taking into account the current trends in the development of housing infrastructure, financial capacity and willingness of the population to improve their living conditions on their own, and on the basis of the estimation of prospective changes in the level of income and society's perceptions of living standards, L. Cherenko (2018) assumes that in the next ten years the development of living conditions will not reach a new level and but it will keep the low rates observed in the last ten years, which will negatively affect the quality of life of Ukrainians. At the same time, O. Ilyash (2015) predicts that the creation of a safe and quality place of living is the basis for the formulation of a strategy of national security of the state. Despite considerable scientific achievements in this area, the problems of interdependence of the components of the level of developing housing and communal infrastructure and the quality of life of the population have not been fully investigated. The need to develop a methodology for assessing the level of development of housing and communal infrastructure and establishing its impact on the quality of life of the population remains urgent. Such a methodology should include tools for a sequential prediction of prospective transformations in housing and communal infrastructure and a qualitative assessment of factor influences on the dynamics of the given field.

2. AIMS

The purpose of the given paper is to economic assessment of the relationship between factors of development of housing and communal infrastructure and the quality of life of the population of Ukraine.

3. METHODOLOGY

Undoubtedly, in the process of drawing up an algorithm for assessing the interconnection and interdependence of the population's quality of life and the factors of development of housing and communal infrastructure, at the first stage of the study, we formed a system of indicators of the development level of housing and communal infrastructure and grouped them into three functional components of housing and communal infrastructure: a) housing stock (seven indicators); b) housing stock improvement (five indicators); c) improvement of the adjoining territories (sixteen indicators). The indicators of each of the three groups were analysed in dynamics over twelve years. Afterwards, we used a correlation-regression analysis, which makes it possible: a) to outline the general pattern that characterises the dependence of correlated variables, that is, to develop a mathematical model of communication (the objective of a regression analysis); b) to determine the closeness of the connection (the objective of a correlation analysis - Leshchinskyi et al., 2008). It is worth noting that to represent the results of calculating pairwise correlation of all pairs of variables, we employed a special method of displaying correlations - a map of correlations using the corrplot function of the programming language R (Kozlovskyi et al., 2018). At the second stage of the study, in order to find a single generalised integral index among a large number of indicators, we used a taxonomy method, the advantage of which is the lack of pre-selection of subsets of strongly correlated features and which does not lead to the selection of several uncorrelated factors (Hrynkevych and Gural, 2016). Thus, taxonomic indicators of the development level of components of housing and communal infrastructure were calculated. To determine the relationship between taxonomic indices and the component of the population's quality of life by using regression equations and applying a least squares method (to determine the optimal trend model), we subsequently constructed econometric models, the adequacy of which was proved by using hypothesis testing with the help of the Fisher's criterion (F-criterion). At the third stage of the assessment, we clustered and grouped the regions of Ukraine according to the level of correlation of the taxonomic indicator of the development level of housing stock improvement and the population's quality of life using Ward's hierarchical method. A cluster analysis not only helps to build scientifically sound classifications, identify internal relationships between units of the observed totality, but also provide compressed information. The proposed Ward's method among all cluster analysis methods has a different approach to assessing cluster proximity. At each step, the grouping is performed for those clusters for which the increase of the intra-cluster dispersion as a result of uniting will be smallest. The advantage of the method is that as a result, clusters of approximately the same size are formed, which geometrically have the shape of hyperspheres (Kozlovskyi et al., 2019). At the fourth stage of the assessment, we made a forecast for the development of housing and communal infrastructure using an exponential smoothing method (Koziuk et al., 2020). The essence of this method is that each element of the time series is smoothed out by means of a weighted moving average, and its weight is reduced by the distance from the end of the dynamic series (Senyshyn, 2014). We would also like to add that the development of housing and communal infrastructure is characterised by jump-like states, which require consideration of the trend factor that influences the results of the forecast. Therefore, Holt's method of linear exponential smoothing with the use of the damping parameter was chosen. Finally, forecasting gives the opportunity to formulate measures for reforming and modernising housing and communal infrastructure and avoid risks that will lead to the deterioration of the quality of life of the population.

4. RESULTS

Ensuring the quality of life of the population is a major prerequisite for reducing social risks and threats, in particular, exacerbation of social tension, housing problems and it is an effective tool for solving socio-economic problems. In addition, the significance of the impact of developing housing and communal infrastructure and the quality of life of the population of Ukraine is highly underestimated and is not taken into account in the integrated assessment of national security of the state. Therefore, it is necessary to establish and evaluate the statistical dependence of the quality of life and the indicators of development of housing and communal infrastructure using multidimensional descriptive statistics and/or multidimensional statistical analysis. Hence, in order to investigate the dependence of the indicator of the quality of life on a number of indicators of the development of housing and communal infrastructure, we consider it appropriate to first determine the correlation coefficients of all variables and choose among them the most dependent ones. We want to note that the most popular measure of the dependence between the two variables is the Pearson correlation coefficient. Thus, for each observed object, two numerical characteristics - variables – X and Y, are measured. Let us denote Xj, Yj – the values of these characteristics for the *j*-th object in the sample (j = 1,..., n). Therefore, the sample covariance of the variables X and Y is called cov(X, Y) = $\frac{1}{n}\sum_{j=1}^{n}(Xj - \bar{X})(Yj - \bar{Y})$, where, $\bar{X}, \bar{Y}$ are the mean values of the given variables, and n is the sample size. The corrected sample covariance is called $cov_0(X, Y)$ = $\frac{1}{n-1}\sum_{j=1}^{n}(Xj - \bar{X})(Yj - \bar{Y})$. Thus, the Pearson correlation coefficient is determined by the formula:

$$(X, Y) = \frac{cov(X,Y)}{\sqrt{S^2(X)S^2(Y)}} = \frac{cov_0(X,Y)}{\sqrt{S_0^2(X)S_0^2(Y)}}, \tag{1}$$

where, $S^2(X)S^2(Y)$ — sample variances X and Y
$S_0^2(X)S_0^2(Y)$ — corrected sample variances.

It should be added that the absolute correlation coefficient does not exceed 1: | r (X, Y) | ≤ 1 and equals ± 1 if and only when there is a strict linear dependence between X and Y in the sample, i.e. there are such numbers b_0, b_1 that $Y_j = b_0 + b_1X_j$.. In this case, all points on the scatterplot will lie on one straight line. The sign r (X, Y) corresponds to the sign $b1$. The correlation coefficient does not change with the linear increasing change of the measurement scale X and Y: if, for example, we consider $X'_j = a_1X_j + a_0$, $a_1 > 0$, then (X', Y) = (X,). We would like to mention that if $a1$ <0, the correlation changes a sign: $r(X', Y) = -r(X, Y)$. We want to note that if the variables X and Y are independent, then, for large sample sizes, r (X, Y) will be close to 0. Independence in the statistical value is considered a situation, when Y and X are independent, if knowing X does not help to predict the value of Y (R. Maiboroda, 2018). Let us note that, given a large number of variables to represent the results of the pairwise correlation calculation of all pairs of variables, we have chosen a special method of displaying correlations - a map of correlations using the function corrplot of the programming language R. Therefore, we consider it necessary to determine the closeness of the relationship and influence of the indicators of development of housing and communal infrastructure on the standard of living of the population through the component of the quality of people's life, as an integrated assessment that takes into account all three dimensions of sustainable development, and reflects the connection between three inseparable spheres of social development: economic, environmental and social (Zghurovskyi, 2019). Thus, for the formation of the correlation map, the component of the quality of life (U) will be the dependent one, and the independent component will be 28 indicators of development of housing and communal infrastructure for 2006-2017, which act as an information base and are presented in table. 1.

$$Y = \begin{pmatrix} 0{,}862 \\ 0{,}831 \\ 0{,}807 \\ 0{,}808 \\ 0{,}807 \\ 0{,}795 \\ 0{,}794 \\ 0{,}792 \\ 0{,}832 \\ 0{,}801 \\ 0{,}817 \\ 0{,}824 \end{pmatrix}, \tag{2}$$

Therefore, it is considered that the deterioration of the development level of housing and communal infrastructure (as its functional components) has an effect on the reduction of the quality of life of the population. The table 1 represents figure legends of the indicators of the development level of housing and communal infrastructure.

Table 1. Figure legends of the indicators of the development level of housing and communal infrastructure

№ s/n	Indicator	Figure legend of an indicator
	Housing stock	
1.	Average size of floor space per person, m2	X1
2.	Total floor area of housing per household that has been put into operation, m2	X2
3.	Index of housing prices,%	X3
4.	Level of utility payment,% Utilities price index,%	X4
5.	Index of utilities prices,%	X5
6.	Level of subsidy coverage in the total number of applications,%	X6
7.	Subsidy cost per household, UAH / household	X7
	Housing stock improvement	
8.	Share of total floor space equipped with water supply,%	X8
9.	Share of total floor space equipped with sewage,%	X9
10.	Share of total floor space equipped with central heating,%	X10
11.	Share of total floor space equipped with gas,%	X11
12.	Share of total floor space equipped with hot water supply,%	X12
	Adjacent territories improvement	
13.	Level of household provision with landfills and shooting ranges, household / unit	X13
14.	Proportion of landfills and shooting ranges that do not meet environmental safety standards in the total number of landfills and shooting ranges,%	X14
15.	Share of landfills overload in the total number of landfills and shooting ranges,%	X15
16.	Level of the population coverage by SDW collection services,%	X16
17.	Wear of special vehicles,%	X17
18.	Level of households coverage by unauthorized landfills, per 10 thousand people	X18
19.	Level of the population coverage by burial places, one per 10 thousand people	X19
20.	Level of using funds for the improvement of burial places in the total amount of financing the improvement of burial places,%	X20
21.	Average cost of one burial, UAH	X21
22.	Level of the population coverage by parking spaces, one per 10 thousand people	X22
23.	Share of parking spaces for disabled people,%	X23
24.	Average charge for parking services, UAH / hour	X24
25.	Area of green spaces for general use, ha per 10 inhabitants	X25
26.	Maintenance costs of 1 hectare of green space for public use, thousand UAH / ha	X26
27.	Level of the area coverage of land plantations for general use by the activity of specialized enterprises, ha / unit	X27
28.	Share of expenditure on electricity consumed by outdoor lighting in the total cost of maintaining it,%	X28

Source: developed by the authors

Thus, according to the conducted correlation analysis, namely the determination of the correlation coefficient of the interconnection between the indicators of the development level of housing and communal infrastructure, the following indicators have the strongest influence on the components of the quality of life of the population: X25 - green areas for public use (-0.93); X27 - the area coverage of land plantations for general use by the activity of specialized enterprises (-0.81); X14 – the share of landfills and shooting ranges that do not meet the environmental safety standards in the total number of landfills and shooting ranges (0.64); X3 – the index of housing prices (0.67); X2 - the total area of housing per household that has been put into operation (0.53); X18 – the level of households coverage by unauthorized landfills (-0.55). It is worth noting that the correlation indices of the interconnection between some of the above indicators and the components of the quality of life are negative, which means that if any indicator increases, the quality of life will decrease. However, in order to better determine the closeness of the relationship and the impact of the indicators on the component of the population's quality of life, it is advisable to consider the aggregate indicator of the development level of housing and communal infrastructure in terms of its functional components, namely: a taxonomic indicator of the development level of housing stock, a taxonomic indicator of the development level of housing stock improvement and taxonomic indicator of the development level of adjacent territories improvement. Therefore, to determine the closeness of the relationship between the taxonomic index of housing stock development, housing stock improvement and adjacent territories improvement that describe the change in the component of the quality of life of Ukraine's population, we will construct an econometric model using a regression equation system and a least squares method. The input data for correlation-regression analysis are presented in table. 2.

Table 2. Input data to assess the closeness of the relationship between the component of the population's quality of life and taxonomic indicators of the development level of the components of Ukraine's housing and communal infrastructure

Years	Component of the quality of life of the Ukrainian population (Y)	Taxonomic indicator of the development level of housing stock (X1)	Taxonomic indicator of the development level of housing stock improvement (X2)	Taxonomic indicator of the development level of adjacent territories improvement (X3)
2006	0,862	0,170	0,630	0,430
2007	0,831	0,205	0,406	0,351
2008	0,826	0,204	0,367	0,330
2009	0,808	0,235	0,256	0,313
2010	0,807	0,279	0,109	0,279
2011	0,795	0,306	0,212	0,309
2012	0,794	0,314	0,148	0,292
2013	0,792	0,311	0,181	0,140
2014	0,832	0,372	0,534	0,065
2015	0,801	0,564	0,643	0,060
2016	0,817	0,851	0,427	0,195
2017	0,824	0,432	0,256	0,181

Source: developed by the authors

We would like to mention that it is reasonable to interpret the relationship between the variables studied as an inaccurate analogue of some strict functional dependence. For example, we observe n objects numbered with the index j = 1,. . . , n, and each is described by the variables Y_j , X_j^1, . . . , X_j^m , where m is a fixed number. We are interested in: how to predict the value of the variable Y for new objects (for which Y was not observed) by the values of X^1,. . . , X^m. To do this, we introduce the following model

$$Y_j = g\left(X_j^1, \dots X_j^m\right) + \varepsilon_j, \tag{3}$$

where g: $R^m \rightarrow R$ is an unknown function called a regression function and ε_j is a random regression error. The variable Y, which is predicted according to others, is called the response, and the variables X^i, i = 1, . . . ,, used for forecasting are called regressors. The model is called the classic regression model. Thus, we describe the relation between the response and the regressors as an approximate functional dependence $Y \approx (X^1, . . . ,)$ and try to evaluate the regression function g, and we interpret the observed deviations from this dependence as random errors of no interest to us. In this approach, we focus on estimating g, and the properties of errors are interesting only when they can be useful for estimating the regression function, testing its hypotheses, or for predicting it. This is called the regression approach to the statistical analysis of multivariate data (Maiboroda, 2018). Thus, the classical linear regression model for describing the dependence of the variable Y on the variables $X^1, \ldots, X^m$ will look like:

$$Y_j = b_0 + b_1 X_j^1 + \cdots + b_m X_j^m + \varepsilon_j \tag{4}$$

where the index $j = 1, \ldots, n$ denotes the observation number in the sample, Yj is the response value for the j −th observation, X_j^1, ... X_j^m is the value of the regressors for j-th observation, ε_j is a random regression error (not observed), b_i, $i = 0, \ldots$ are unknown regression coefficients that have to be estimated from observations.

The least squares functional is the following model:

$$J(b) = \sum_{j=1}^{n} (Y_j - b_0 - \sum_{i=1}^{m} b_i X_j^i)^2 \tag{5}$$

(here b = $(b_0, b_1, \ldots, b_m)^T$ is the vector of possible values of the regression coefficients).

The estimate of the least squares method is defined as that is $\hat{b} = argmin\, J(b), b \in R^{m+1}$, so it is a set of regression coefficients on which the functional of the least-squares method reaches the least value (Maiboroda, 2018). The correlation-regression analysis of factor traits for identifying the closeness of the relationship was conducted using the program R. Table 3 presents the calculated coefficients for constructing a multiple regression model equation.

Table 3. Calculated coefficients for constructing a multiple regression model equation

Model	B	Standard error	t	P-value	VIF
Constant	0,775	0,021	36,710	0,000	
X1	-0,014	0,029	-0,490	0,637	1,582
X2	0,081	0,024	3,342	0,010	1,054
X3	0,073	0,047	1,561	0,157	1,553

Source: developed by the authors

Hence, the data in Table 3 indicate the low level of significance of the coefficients X1 (taxonomic indicator of the development level of housing stock) and X3 (taxonomic indicator of the development level of adjacent territories), since there is an imbalance where p-value> α (where α = 0,05). Therefore, to build an adequate model of the interconnection, we exclude these two indicators and build a new model that reflects the closeness of the impact of housing stock improvement on the component of the population's quality of life. In table 4, the calculated coefficients for constructing a new equation of the linear regression model are presented.

Table 4. Calculated coefficients for constructing an equation of the linear regression model

Model	B	Standard error	t	P-value
Constant	0,785576	0,007245	108,429	2e-16
X2	0,094048	0,018604	5,055	0,000495

Source: developed by the authors

In continuation of the research, on the basis of the calculated coefficients, we will construct a linear regression model:

$$Y = 0{,}786 + 0{,}094*X2, \tag{6}$$

where Y is the existing linear relationship between the component of the quality of life of Ukraine's population and the development level of Ukraine's housing stock improvement, which demonstrates a direct impact of the latter (b_1 = 0,094) on Ukraine's economic security through the quality of life of the population. Therefore, according to the regression model, the value of the component of the population's quality of life increases if the taxonomic index of the development level of housing stock improvement rises. We want to note that in order to evaluate the quality of the model obtained, it is necessary to calculate the coefficients of multiple correlation and determination. Thus, the multiple correlation coefficient is calculated by the formula:

$$R = \frac{\sum_{j=1}^{n}(Y_j - \bar{Y})(\hat{Y}_j - \widehat{\bar{Y}})}{\sqrt{\sum_{j=1}^{n}(Y_j - \bar{Y})^2 \sum_{j=1}^{n}(\hat{Y}_j - \bar{\hat{Y}})^2}}. \quad (7)$$

This value reflects the relationship between the values of the dependent and independent variables. The values of the correlation coefficient can vary in the range from 0 to 1. As the coefficient approaches 1, the relationship is strengthened. If R is greater than 0.5, then there is a relationship between the variables, and vice versa. The coefficient of determination of the linear regression model is calculated by the formula:

$$R^2 = \frac{\sum_{j=1}^{n}(\hat{Y}_j - \hat{Y})^2}{\sum_{j=1}^{n}(Y_j - \bar{Y})^2} = 1 - \frac{\sum_{j=1}^{n} U_j^2}{\sum_{j=1}^{n}(Y_j - \bar{Y})^2}. \quad (8)$$

This value indicates what proportion of the variance (dispersion) of the response is reproduced by the prediction based on this regression model. The coefficient of determination is always non-negative and does not exceed 1:

$$0 \le R^2 \le 1. \quad (9)$$

The higher the coefficient of determination, the more accurate the prediction about the data according to which the regression model was adjusted. Therefore, it is accepted to use R^2 for rough characterisation of the quality of the model. Sometimes, the so-called corrected coefficient of determination is used:

$$R_{adj}^2 = 1 - \frac{\sum_{j=1}^{n} U_j^2/(n-m-1)}{\sum_{j=1}^{n}(Y_j - \bar{Y})^2/(n-1)}, \quad (10)$$

(With this correction, the numerator contains an unbiased estimate for the variance of errors and the denominator contains the unbiased estimate for the variance of the response). Table 5 presents the results of calculating the coefficients of correlation and determination using the program R.

Table 5. Coefficients showing the closeness of the relationship and the results of the variance analysis

R	R-square	Durbin-Watson	F	P-value
0,8478	0,6906	1,387	25,56	0,0004954

Source: developed by the authors

Multiple correlation coefficients indicate that there is a close correlation between the taxonomic index of the development level of housing stock improvement and the component of the population's quality of life in Ukraine (the correlation coefficient is 0.8478). The value of the determination coefficient suggests that the multiple regression model is true for 69.06% of the cases of the processed sample of impact factors. According to the Durbin-Watson test for autocorrelation, the model lacks systematic relationships between residuals; we would like to add that the value of the indicator should be close to 2, in our case - 1,387. To test the constructed model for adequacy, we use hypothesis testing with the help of the Fisher criterion (F-criterion). Thus, there are two hypotheses:

$$H_0 : R^2 = 0,$$
$$H_1 : R^2 \neq 0. \quad (11)$$

The first hypothesis or null hypothesis confirms that the equation under study does not explain the changes in the regressor under the influence of the corresponding regressors, and the second one is an alternative hypothesis. On the contrary, it proves that at least one of the factors influences the change of the dependent variable. F is the Fisher's criterion, which is calculated by the formula:

$$F = \frac{R^2}{1-R^2} \cdot \frac{n-k}{m} \ . \tag{12}$$

The experimental value F - the Fisher's criterion is compared with the table value of the Fisher distribution at a given level of significance α (usually α = 0.05. α = 0.01). If, $F_{tabl} < F_{exp,}$ the null hypothesis is rejected, that is, there is such a coefficient in the regression equation that is significantly different from zero, and the corresponding factor influences the variable under study. The rejection of the null hypothesis testifies to the adequacy of the constructed model (Leshchynskyi et al., 2008). With the help of R software, p-value is used to test hypotheses. Thus, if p-value $<\alpha$, one accepts the alternative – there is dependence between Y and X, the regressor is significant; if p-value> α, one accepts the main hypothesis — the dependence between Y and X is not detected, the regressor is insignificant. Table 3.5 shows the results of calculating the indicators of model adequacy using the program R. Therefore, according to the analysis, for the component of the quality of life p-value = 0.0004954, which allows rejecting the null hypothesis when α = 0.05; so, the difference between the null hypothesis and the sample data is statistically significant, which proves the hypothesis that changes in the development level of housing stock improvement affect the change in the component of the population's quality of life.

It should be noted that in the regional context, the indicators of the interconnection have different factors of influence, which leads to differentiation of their values. Therefore, for the distribution of territorial units of Ukraine by the level of the interconnection of the taxonomic indicator showing the development level of housing stock improvement and the quality of life of the population, we will conduct a cluster analysis of the data. Clustering (or cluster analysis) is the process of dividing a set of data (or objects) into a set of meaningful subclasses called clusters. Clusters, in our case, made it possible to understand the natural grouping or structure in a set of data and to group multidimensional objects by the results of individual observations using points of geometric space, followed by the selection of groups of these points (Putrenko and Krasovskaya, 2015). Therefore, we have employed the following algorithm for carrying out the cluster analysis (A. Tkachova, 2012): 1) determining the purpose of clustering; 2) forming a sample of clustering objects; 3) selecting indicators on the basis of which the analysis will be carried out; 4) forming key data matrix; 5) bringing the values of the indicators for each object to a comparable scale (standardisation of indicators); 6) choosing a cluster analysis method; 7) conducting the cluster analysis by the chosen method. It is worth adding that the purpose of clustering the territorial units of Ukraine by the level of correlation between the taxonomic index of housing stock improvement and the quality of life of the population is to divide the regions of Ukraine into clusters by similar objects in order to assess socio-economic development of a region or group of regions. To carry out an analysis, we have selected 24 objects (regions of Ukraine), each of which is characterised by 2 indicators: a component of the quality of life of the population and a taxonomic indicator of the development level of housing stock improvement of Ukraine. The initial data for the cluster analysis are presented in table 6.

Table 6. Initial data for conducting a cluster analysis of Ukrainian regions by the level of correlation between the taxonomic index of the development level of housing stock improvement and the quality of life of the population, 2016.

№ n/s	*Oblasts*	*Component of the quality of life*	*Taxonomic indicator of the development level of housing stock improvement*
1.	Vinnytsia	0,804	0,933
2.	Volyn	0,805	0,857
3.	Dnipropetrovsk	0,764	0,508
4.	Donetsk	0,611	0,589
5.	Zhytomyr	0,816	0,919

6.	Zakarpattia	0,869	0,987
7.	Zaporizhzhia	0,712	0,668
8.	Ivano-Frankivsk	0,776	0,771
9.	Kyiv	0,818	0,931
10.	Kirovohrad	0,750	0,802
11.	Luhansk	0,701	0,553
12.	Lviv	0,829	0,766
13.	Mykolaiv	0,767	0,492
14.	Odesa	0,748	0,471
15.	Poltava	0,793	0,853
16.	Rivne	0,804	0,947
17.	Sumy	0,745	0,666
18.	Ternopil	0,812	0,959
19.	Kharkiv	0,856	0,280
20.	Kherson	0,756	0,418
21.	Khmelnytskyi	0,845	0,766
22.	Cherkasy	0,777	0,813
23.	Chernivtsi	0,827	0,920
24.	Chernihiv	0,776	0,426

Source: developed by the authors

The cluster analysis will be carried out using Ward's hierarchical clustering method, which is based on the determination of distances between objects. Therefore, it is expedient to use geometrically represented metrics to join objects in groups that are typical of weakly correlated sets. The formula for calculating the Euclidean distance *d (zi, zj)* is as follows (S. Yermak, 2017):

$$d\ (zi, zj) = \sqrt{\sum_{k-1}^{\rho} (z_{ij} - z_{jk})^2}, \tag{13}$$

where z_{ij} is the standardized value of the j-th object by the i-th index;
z_{jk} is the standardized value of the k-th object by the j-th index.

The results of the cluster analysis using the Ward hierarchical method were obtained with the help of the IBM SPSS Statistics software package. Thus, as a result of the hierarchical cluster analysis of the relationship between the taxonomic index of the development level of housing stock improvement and the quality of life of the population, we can unite regions of Ukraine into 4 clusters: cluster №1 (Vinnytsia, Zhytomyr, Zakarpattia, Kyiv, Rivne, Ternopil, Chernivtsi), cluster №2 (Volyn, Ivano-Frankivsk, Kirovohrad, Lviv, Poltava, Khmelnitskyi, Cherkasy), cluster №3 (Dnipropetrovsk, Mykolaiv, Odesa, Kharkiv, Kherson, Chernihiv), cluster №4 (Donetsk, Zaporizhzhia, Luhansk, Sumy). In addition, there are 4 levels of interconnection based on the grouping of Ukrainian regions:

– high, with an average value of the component of the quality of life 0,821 throughout the group and the level of development of housing stock improvement - 0,942;
– average, with the average value of the component of the quality of life 0.796 throughout the group and the level of development of housing stock improvement - 0.804;
– below average, with the average value of the component of the quality of life 0.778 throughout the group and the level of development of housing stock improvement - 0.433;
– low, with the average value of the component of the quality of life 0.692 throughout the group and the level of development of housing stock improvement - 0.619.

The average value of the population's quality of life in Ukraine is 0.782, while the level of development of housing stock improvement is 0.721. It should be noted that in the 3rd cluster, there is a rather high index of the quality of life (0.778), however, the level of housing stock improvement is extremely low (0.433). The table 7 presents the results of grouping the regions of Ukraine on the basis of the relationship between the taxonomic indicator of the development level of housing stock improvement and the population's quality of life in 2016. Group average values of the indicators (spatial grouping of regions of Ukraine by the indicated feature of dependence).

Table 7. Grouping the regions of Ukraine on the basis of the correlation between the taxonomic index of the development level of housing stock improvement and the population's quality of life, 2016

Clusters	*The level of interconnection*	*Oblasts*	*Component of the quality of life*	*Taxonomic indicator of the development level of housing stock improvement*
1	High	Vinnytsia, Zhytomyr, Zakarpattia, Kyiv, Rivne, Ternopil, Chernivtsi	0,821	0,942
2	Average	Volyn, Ivano-Frankivsk, Kirovohrad, Lviv, Poltava, Khmelnytskyi, Cherkasy	0,796	0,804
3	Below average	Dnipropetrovsk, Mykolaiv, Odesa, Kharkiv, Kherson, Chernihiv	0,778	0,433
4	Low	Donetsk, Zaporizhzhia, Luhansk, Sumy	0,692	0,619
Total	-	-	0,782	0,721

Source: developed by the authors

Thus, spatial grouping of the regions attests to the territorial integrity of Ukraine. However, in western and central regions of Ukraine, housing policy is more effective than in the regions with high industrial potential. It should be mentioned that in the areas bordering the Russian Federation and the temporarily occupied territories of Donetsk and Luhansk oblasts, namely Sumy, Luhansk, Donetsk and Zaporizhzhia, the population's quality of life and the level of development of housing stock improvement are the lowest, which increases social tension and social inequality in society. The uncertainty of the state of housing and communal infrastructure in the future dictates the need to find new effective mechanisms for state housing policy. Moreover, new challenges of economic development of the state need the implementation of effective social policies in order to provide the population with decent and comfortable living conditions. Therefore, the development of housing and communal infrastructure requires the effective forecasting and application of economic and mathematical models of future changes and the assessment of factor influences on the quality of life of the population using foresight methods. Extrapolation methods are used in the process of forecasting time series. We want to add that the basis of extrapolation methods is the dynamic series, that is, the sequence of indicators that characterise the change in the phenomenon over time. In order to effectively predict the development of housing and communal infrastructure, it is necessary to employ one of the methods of adaptive forecasting, which belongs to complex extrapolation methods, in particular, the exponential smoothing method. Thus, Holt's method of linear exponential smoothing has been employed to predict the development level of housing and communal infrastructure. We want to note that this method uses prediction data for forecasting as well as two smoothing parameters: α and β * (with values from 0 to 1) and three equations) (Hyndman et al., 2008):

- time series equation: $l_t = \alpha y_t + (1-\alpha)(l_{t-1} + b_{t-1})$;
- time trend equation: $b_t = \beta^* (l_t - l_{t-1}) + (1 - \beta^*) b_{t-1}$;
- forecast equation: $\widehat{y_{t+h|t}} = l_t + b_t h$,

where l_t is an estimate of the level of the time series (t);
b_t is an estimate of the trend of the time series;
α is the smoothing parameter for the level;
β* is the smoothing parameter for the trend. However, the smaller the value of β*, the less the slope of the trend changes with time.

According to these equations, the forecast function is trending, hence the forecast is equal to the last estimated time series value and includes the last estimated time trend value. It is worth noting that the forecasts for the development of housing and communal infrastructure, generated by the Holt's method of linear exponential smoothing, show a constant tendency (increase or decrease) infinitely into the future, therefore, the method tends to over-forecast, especially when it comes to longer forecasts. That is why, we consider it appropriate to further calculate the forecast of housing and communal infrastructure by entering a damping parameter φ ($0 < \varphi < 1$), which for some time in the future will «offset» the trend of the flat line. Thus, the equations take the following form (Hyndman et al., 2018):

– the equation of the level of time series: $l_t = \alpha y_t + (1-\alpha)(l_{t-1} + \varphi b_{t-1})$;
– time trend equation: $b_t = \beta^* (l_t - l_{t-1}) + (1 - \beta^*) \varphi b_{t-1}$;
– the forecast equation: $\widehat{y_{t+h|t}} = l_t + (\varphi + \varphi^2 + \dots + \varphi^h) b_t$,

If φ = 1, the method is identical to Holt's method of linear exponential smoothing. For values between 0 and 1, φ - dampens the trend so that it approaches a constant for some time in the future. Indeed, the prediction comes down to $l_t + \varphi b_t / (1-\varphi)$, when $h \to \infty$ for any value $0 < \varphi < 1$. This means that short-term projections of the development of housing and communal infrastructure tend to increase, while long-term predictions for housing stock are stable. In general, φ less than 0.8 is used in forecasting, since damping has a significant effect on a decrease of the indices. A value of φ close to 1 means that the damped model does not differ from the undamped one. Therefore, the values of φ between 0.8 and 0.98 are usually used.

Forecasts on the development level of housing and communal infrastructure in general and in terms of its functional components (housing stock, housing stock improvement and improvement of the adjacent territories), were made using the function Holt of the programming language R. The forecast of the development level was made for a period of 10 years at α = 0.8, β* = 0.2 and φ = 0.9. The results of the forecast are presented in table 8.

Table 8. The results of forecasting the development level of housing and communal infrastructure

Years	*Component 1(housing stock development)*		*Component 2 (development of housing stock improvement)*		*Component 3(development of adjacent territories improvement)*		*In general, by all components (development of housing and communal infrastructure)*	
	Holt's method	*Holt's damping method*	*Holt's method*	*Holt's damping method*	*Holt's method*	*Holt's damping method*	*Holt's method*	*Holt's damping method*
2019	0,351	0,340	0,237	0,239	0,073	0,082	0,117	0,113
2020	0,325	0,310	0,207	0,214	0,052	0,068	0,094	0,091
2021	0,300	0,284	0,177	0,192	0,030	0,055	0,072	0,071
2022	0,274	0,260	0,147	0,172	0,008	0,044	0,049	0,053
2023	0,249	0,239	0,117	0,154	-0,014	0,034	0,027	0,037
2024	0,223	0,219	0,087	0,138	-0,036	0,025	0,004	0,022
2025	0,198	0,202	0,057	0,123	-0,057	0,017	-0,018	0,009
2026	0,172	0,186	0,027	0,110	-0,079	0,010	-0,041	-0,003
2027	0,147	0,172	-0,003	0,098	-0,101	0,003	-0,063	-0,013
2028	0,121	0,160	-0,033	0,087	-0,123	-0,003	-0,086	-0,023
α	0,8		0,8		0,8		0,8	
β*	0,2		0,2		0,2		0,2	
φ	-	0,9	-	0,9	-	0,9	-	0,9

Source: developed by the authors

Hence, according to Holt's forecast model, the development level of housing and communal infrastructure for the period until 2028 will continue to decline, unless the necessary measures are taken to reform and modernise housing and communal infrastructure, and in 5 years' time it will be only 0.037. We would like to mention that there is a decline in the development of each component of housing and communal infrastructure, however, the greatest impact on the overall indicator of the development of housing and communal infrastructure is made by the development level of the component of adjacent territories improvement, which in 2023 will be only 0.034. Thus, the neglect of solving the problems of previous years and the lack of effective reforms in the sphere of housing policy creates a number of threats to the quality of life of the population due to the inability of the state to satisfy people’s needs for comfortable living conditions. At the same time, the classification of the regions of Ukraine by the quality of life of the population and the development level of housing stock improvement allows us to study in more detail the problematic places directly at the regional level and stimulate the formation of Regional strategies and programs of housing policy of Ukraine.

5. DISCUSSION

Generalising the scientific controversy over the interpretation of quality of life, we have come to the conclusion that "quality of life" is a complex category that characterises the well-being of citizens of the country, assesses their perception of the natural, economic, socio-political and social environment. The natural environment is characterised by the ecological situation and the quality of the environment. The economic environment is characterised by external conditions related to citizens' participation in economic activity and income, including paid work, the economic situation and finances. The socio-political environment is characterised by social policy and the degree of development of civil society. The social environment covers the conditions associated with different types of social activity of people (social opportunities, leisure, education, access to support and maintenance of health, its state, participation in democratic processes), as well as the development of social infrastructure (the system of education and professional training, healthcare, transportation, communications, culture, living conditions and security of living). Of course, each of these components has an impact on the performance indicators of the quality of life and economic security. However, the aim of this article is to explore the relationship between the components of the social environment, including the development of housing and communal infrastructure, improvements - and the quality of life, as we consider housing to be a place where one's personal needs and interests are protected, and one's psychological microclimate and health are maintained, where the principles of social integration and healthy coexistence are nurtured. In turn, living conditions reflect the provision of adequate physical, hygienic, aesthetic and other conditions of people’s lives, their safety and comfort, and are a guarantee of safety not only at the micro, but also at the macro levels.

It is extremely disturbing that in Ukraine 51.7% of families (over 8.8 million families) do not have the minimum necessary living conditions. Furthermore, the worst situation with the provision of rooms in accordance with the EU-SILC standard is minus 1. The number of rooms that 5.6 million families (32.9%) possess is smaller than this standard. 13.2% of families live in homes with less than 13.65 m^2 of floor space per family member. One in every four households in Ukraine (24.9%) does not have access to water supply or sewerage system. The state of the system of centralized water supply and sewerage systems in Ukraine is critical and requires retrofitting and renewal works. Only 22.5% of Ukrainian families are provided with normal living conditions. The main point is the absence of the required number of rooms according to EU-SILC standards (63.7% of the households in Ukraine do not meet them). 4.9 million families or 28.8% have no comfortable conditions for maintaining body hygiene, which is not much more than the total proportion of families deprived of access to water supply and sewage system (Kohatko, 2019). This situation is worrying because it is clear that the higher the housing stock improvement, the lower the loss of potential years of life of the population. All this has a very negative impact on the possibilities of human development and self-actualization. The results of sociological surveys show a major influence of housing issues on demographic indicators: the indicator of the availability of adequate housing conditions is the third most important factor for making a decision on the birth of a child (about 55% of respondents) and it is the second in determining the desired number of children in a family. When deciding to start a family, 20% of respondents find the lack of their own accommodation a negative factor. Housing problems are one of the driving forces behind migration in Ukraine. According to a survey conducted by the All-Ukrainian Association for International Employment, one of the main reasons making people work abroad is the inability to earn money to buy dwelling in Ukraine, and 29% of the country's population uses the money of their families that work and live abroad in order to solve their housing problems, (NISD, 2018).

CONCLUSIONS

The article evaluates the stochastic dependence of the development level of housing and communal infrastructure and the development level of housing stock improvement through the component of the population's quality of life. As a result of the research, a linear relationship between the component of the quality of life of the Ukrainian population and the development level of housing and communal infrastructure, in particular, the improvement of the housing stock of Ukraine, was proved. The correlation-regression analysis made it possible to group the regions of Ukraine according to the level of provision of living conditions for citizens and to choose territorial units that need priority measures of housing policy. The cluster analysis of territorial units of Ukraine by the level of correlation of the taxonomic indicator of housing stock improvement and the population's quality of life consists in dividing the regions of Ukraine with the purpose of clustering by similar objects in order to assess socio-economic development of a region or group of regions according to the level of development in general across Ukraine. The cluster analysis revealed that housing policy in the western and central regions of Ukraine is more effective than in the regions with high industrial potential. In addition, in the regions bordering the Russian Federation and the temporarily occupied territories of Donetsk and Luhansk oblasts, namely Sumy, Luhansk, Donetsk and Zaporizhzhia, the quality of life of the population and the development level of housing stock improvement are the lowest, which increases social tension and negative social sentiments.

The study suggested improving the predictive model of development of housing and communal infrastructure, which differs from the existing ones in accuracy of the predicted values due to the use of R programming language and Holt's forecasting model. This made it possible to calculate the development level of housing and communal infrastructure for the period up to 2028, both as a whole and in terms of individual functional components, formulate measures for reforming and modernising housing and communal infrastructure and avoid risks that will lead to deterioration in the quality of life of the population. The exponential smoothing method used in forecasting the development level of housing and communal infrastructure helped to find out that if the necessary measures are not taken to reform and modernise housing and communal infrastructure, its development will decline (in 5 years it will be only 0.037). Furthermore, if one neglects the problems of development of housing and communal infrastructure, it will further lead to social, environmental and man-made disasters. The authors are convinced that the diagnosis of the strengths pertaining to housing stock will allow in the future taking advantage of the internal capabilities of housing and communal infrastructure and avoiding the risks that will lead to deterioration of the standard and quality of life of the population.

REFERENCES

Besbris, M., Faber, J.W. (2017), "Investigating the Relationship Between Real Estate Agents, Segregation, and House Prices: Steering and Upselling in New York State", *Sociol Forum,* Vol. 32, pp. 850-873.

Cherenko, L.M. (2018), “Housing conditions of the population and choice of priority areas of housing policy”, *Demography and Social Economy,* Vol. 1(32), pp. 126-139 (in Ukrainian).

Conley, D. (2001), “A Room with a View or a Room of One's Own? Housing and Social Stratification”, *Sociological Forum,* Vol. 16, No. 2, pp. 263-280.

Dwyer, R.E. (2007), “Expanding homes and increasing inequalities: U.S. housing development and the residential segregation of the affluent”, *Social problem,* Vol. 54, No. 1, pp. 23-46.

Hrynkevych, S.S., Gural, N.R. (2016), “Assessment of labour potential renovation for trade enterprises”, *Economic Annals-XXI,* Vol. 160, No. 7-8, pp. 96-99 (in Ukrainian).

Hyndman, R.J., Koehler, A.B., Ord, J.K., Snyder, R.D. (2008), *Forecasting with Exponential Smoothing: The State Space Approach,* Springer, Berlin.

Hyndman, R., Athanasopoulos, G. (2018), *Forecasting: principles and practice*, 2nd Ed., Melbourne.

Ilyash, O. (2015), “Strategic priorities of Ukraine’s social security concept development and implementation”, *Economic Annals-XXI,* Vol. 7-8, No. 1, pp. 20-23 (in Ukrainian).

Kohatko, Y.L. (2019), “Improving the living conditions of the Ukrainian population: assesment, needs”, *Demography and social economy,* Vol. 4(38), pp. 86-102 (in Ukrainian).

Korver-Glenn, E. (2018), “Compounding Inequalities: How Racial Stereotypes and Discrimination Accumulate across the Stages of Housing Exchange”, *American Sociological Review*, Vol. 83(4), pp. 627-656.

Koziuk, V., Hayda, Y., Dluhopolskyi, O, Kozlovskyi, S. (2020), “Ecological performance: ethnic fragmentation versus governance quality and sustainable development”, *Problems of Sustainable Development*, Vol. 15 № 1, pp. 53-64.

Kozlovskyi, S., Shaulska, L., Butyrskyi, A., Burkina, N., Popovskyi, Y. (2018), “The marketing strategy for making optimal managerial decisions by means of smart analytics”, *Innovative Marketing*, Vol. 14, No. 4, pp. 1-18.

Kozlovskyi, S., Butyrskyi, A., Poliakov, B., Bobkova, A., Lavrov R., Ivanyuta, N. (2019), “Management and comprehensive assessment of the probability of bankruptcy of Ukrainian enterprises based on the methods of fuzzy sets theory”, *Problems and Perspectives in Management*, Vol. 17, No. 3, pp. 370-381.

Leshchynskyi, O.L., Riazantsev, V.V., Yunkova, O.O. (2008), *Econometrics*, Personal, Kiev (in Ukrainian)

NISD (2018), *Analytical Report to the Annual Message of the President of Ukraine to the Verkhovna Rada of Ukraine ‘On the internal and external situation of Ukraine in 2018’* (in Ukrainian).

Nguyen-Hoang, P., Yinger, J. (2011). “The Capitalization of School Quality into House Values: A Review”. *Journal of Housing Economics*, Vol. 20, No. 1, pp. 58.

Novikov, V.M. (2018), “Improving housing finance”, *Demography and social economy,* Vol. 3, pp. 86-99 (in Ukrainian).

Owens, A. (2019), “Building Inequality: Housing Segregation and Income Segregation”, *Sociological Science*, Vol. 6, pp. 497-525.

Poliakova, S.V., Kohatko, Y.L. (2017), “Housing conditions in the hierarchy of the needs of the population”, *Global and national problems of the economy,* Vol. 20, pp. 742-746 (in Ukrainian).

Putrenko, V.V., Krasovskaya, I.G., (2015), “Geospatial data clustering in the process of intellectual analysis”, *Electronic and computer systems,* Vol. 3, pp. 45-52 (in Ukrainian).

Senyshyn, O.S. (2014), “Prediction extrapolation method as a tool of optimum product amount of consumption of state food complex”, *Youth Economic Digest,* Vol. 1, No. 1, pp. 26-32 (in Ukrainian).

Shishkin, V.S. (2012), “Statistical estimation of inequality of housing conditions of households”, *Applied statistics: problems of theory and practice,* Vol. 11, pp. 245-253 (in Ukrainian).

Shishkin, V.S. (2016), “Poverty of Ukraine’s population under housing conditions”, *Demography and Social Economy*, Vol. 1, pp. 51-64 (in Ukrainian).

Tyshchenko, O.P. (2015), “European approach to housing development: benchmarks for Ukraine”, *Current problems of the economy,* Vol. 3(165), pp. 301-309 (in Ukrainian).

Vasyltsiv, T.G., Lupak, R.L., Kunytska-Iliash, M.V. (2019), “Social Security of Ukraine and the EU: aspects of convergence and improvement of migration policy”, *Baltic Journal of Economic Studies,* Vol. 5(4), pp. 50-58.

Zghurovskyi, M.Z. (2012), *Analysis of sustainable development: global and regional contexts*, NTUU «KPI», Kyiv (in Ukrainian).