

REPORT

Problems and perspectives on environmental component of quality of life: A case study from the Carpathian region of Ukraine

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Abstract

Quality of life is a complex and multidimensional concept that reflects the level of development across various spheres of society. This paper focuses on one of the most important yet underdeveloped aspects. The study aims to assess the impact of environmental components on the quality of life in the Carpathian region of Ukraine and to present the authors' approach to improving it. Multiple regression analysis was conducted using annual statistical data on mortality rates, air, and water pollutants, gross regional product per capita, and foreign direct investment in the Carpathian region of Ukraine from 2001 to 2020. The analysis showed a direct negative impact of water and air pollution on the mortality rate in the region. The study also noted that foreign investment can sometimes increase mortality, indicating that the Carpathian region may act as a "haven for polluters" for foreign investors, which requires further detailed studies. The Carpathian Eco-Way Strategy was developed to address the region's most urgent ecological issues. It focuses on restoring natural capital, ensuring environmental cleanliness, transitioning to a green economy, and promoting environmentally efficient behavior among residents, visitors, and businesses. The study presents a model of environmentally efficient behavior that illustrates the interaction between legal and informational mechanisms and individual socio-psychological characteristics. Such behavior involves an active component and aims to preserve and improve the environment. The Eco-Way Strategy and model for environmentally efficient behavior development presented in the article are not only applicable to the Carpathian region of Ukraine; they can also be used as a basis for state policy development tools to solve environmental problems in other regions or countries. The authors' methodological approach can serve as the framework for further studies in this field.

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1. Introduction

Quality of life is a key indicator of the social and economic development of countries and regions. Enhancing quality of life has become a primary goal of international development. However, economic growth is often achieved at the expense of natural

resource depletion and environmental pollution. Growing environmental challenges and increasing global awareness of their impact have led to a more comprehensive approach to quality-of-life assessments, incorporating environmental factors. The implementation of the European Green Deal, which seeks to balance economic growth with environmental sustainability, underscores the need to revise quality-of-life standards and emphasizes research on its ecological determinants.

This study evaluates the impact of environmental and economic factors on the quality of life in the Carpathian Region of Ukraine and presents an approach to improving its environmental component.

The Carpathian Region covers nearly one-tenth of Ukraine's territory and consists of four oblasts: Zakarpattia, Ivano-Frankivsk, Lviv, and Chernivtsi. It is a region of significant ecological value, containing 22% of Ukraine's forests, 26% of its nature reserve lands, 36% of its river runoff water resources, and 42% of its rare underground mineral water deposits (Kravtsiv, 2013, p. 6). In addition, the region shares borders with five countries – Poland, Romania, Moldova, Hungary, and Slovakia. As ecological issues do not have clearly defined boundaries, research on environmental problems in this region is of international interest and importance. These factors determined the choice of the Carpathian Region of Ukraine as the object of this study.

The research is significant because it addresses the pressing issue of environmental degradation in the Carpathian region and its direct impact on the quality of life, particularly with regard to mortality rates. The novelty of this research lies in its comprehensive analysis of the interactions between environmental, economic, and social factors within a specific regional context. Unlike other studies that primarily advocate for eco-friendly behavior, this research offers a structured framework for understanding environmentally efficient behavior – an approach aimed at both preserving and improving the environment, which is crucial for the region's sustainable development.

The multiple regression analysis has practical implications, as understanding these dynamics can support policymakers and health professionals in developing strategies to improve life expectancy and public health outcomes. Moreover, the findings from this study contribute to the broader body of knowledge and provide a foundation for future research on mortality and its determinants. The insights gained can also help guide nations in crafting targeted interventions and policies that promote sustainable development and the long-term well-being of human populations. While multiple

regression analysis is considered a standard regression model, it is not inherently robust, as it can be sensitive to outliers, multicollinearity, and violations of assumptions such as linearity and homoscedasticity. Thus, the study underscores the significance of using robust statistical models that can effectively handle violations of these assumptions to inform data-driven decisions that enhance human health and longevity.

The article consists of six sections. The relevance and significance of the study are presented in Section 1. Section 2 provides a literature review and research background. Section 3 highlights the methodological approach and data used in the study. The results of the multiple regression analysis are presented in Section 4. Section 5 is dedicated to the presentation of the Carpathian Eco-Way Strategy. Limitations of the study and main conclusions are covered in Section 6.

1.1. Literature review background

The relevance and urgency of quality-of-life issues have attracted significant interest from scientists and experts. According to Keles (2012), quality of life is a global phenomenon that affects billions of people in both developing and developed countries. It is a broad concept encompassing various aspects of societal well-being (Keles, 2012, p.24) and includes multiple dimensions: Physical, socio-cultural, economic, and environmental. Researchers worldwide have examined the impact of different factors on quality of life. For example, one of the latest publications has shown the positive impact of digital finance development on the population's health (Liping & Minizhe, 2024).

A key focus in modern research is the measurement of quality of life. Conventionally, two main approaches are used: subjective and objective (Ostasiewicz, 2012). Subjective indicators reflect an individual's perception of their quality of life and overall life satisfaction, typically assessed through sociological surveys. In contrast, the objective approach evaluates quality of life based on statistical indicators.

Scientists at the Ptoukha Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine have developed a comprehensive methodology for measuring quality of life that incorporates both subjective and objective indicators (Libanova *et al.*, 2013). In subsequent research, they compared different methodological approaches based on population surveys and subjective assessments used by organizations such as the Organization for Economic Co-operation and Development, the European Union, and the Commonwealth of Independent States (Libanova *et al.*, 2020).

As an important aspect of quality-of-life issues, this article focuses on the environmental component related to the concept of sustainable development. Some researchers (Trusina & Jermolajeva, 2021, p. 298) use the concept of sustainable development to determine the impact of the economic, environmental, and social systems on human development. A high quality of life is sometimes linked to high natural resource consumption, which led to the introduction of the concept of “sustainable quality of life.” This concept emphasizes a balance between maintaining a high standard of living while ensuring ecological and social sustainability (Wiesli *et al.*, 2021). Sustainable development, therefore, involves protecting, preserving, and conserving the natural environment for future generations. Its success depends on achieving environmental stability alongside a high quality of life (Yusoff, 2020).

The primary goal of sustainable development is to enhance quality of life, which is evaluated using various factors and indicators. Among these, the environmental dimension is recognized as one of the most influential (Štreimikienė, 2015).

Modern methodologies for assessing quality of life increasingly incorporate environmental indicators (Rybalova *et al.*, 2021). Ukrainian researchers (Yeliseyeva & Proshkina, 2021) have studied the impact of environmental factors on quality of life by comparing economic and environmental indicators. They also developed the Eco-Index, a set of indicators tailored to Ukraine's specific characteristics (Yeliseyeva & Proshkina, 2021). It is also worth mentioning the investigation of the socioeconomic indicators that affect the quality of life of the population in Ukraine. Four groups of factors related to the socioeconomic situation of Ukrainian households were selected: Economic status (11 factors), education (five), health (three), and population (three) (Kravets & Didenko, 2022).

One of the earliest assessments of the potential consequences of Russia's full-scale war on Ukraine's quality of life was conducted by scientists at the Ptoukha Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine. Drawing on established trends from past decades, the researchers analyzed the war's destructive effects and explored prospects for mitigating its negative impact (Cherenko *et al.*, 2023).

Despite the significance of the concept of “quality of life,” there is still no universally accepted definition. Broadly speaking, “quality” refers to an attribute or set of characteristics inherent in a phenomenon, process, or object. It also denotes the extent to which an object's properties conform to specific standards, scientific norms, or the expectations and needs of individuals, groups, or society as a whole.

The *World Encyclopaedia Britannica* defines quality of life as “the degree to which an individual is healthy, comfortable, and able to participate in or enjoy life events” (Jenkinson, 2016). However, this concept remains ambiguous, as it encompasses both an individual's personal experience and overall living conditions.

To provide a more comprehensive understanding of the quality of life and highlight the importance of its environmental component, Ryndzak (2021, p. 154) proposed the following definition: Quality of life is a complex, multidimensional concept that reflects the level and sustainability of social development and characterizes population and their living environment, as well as human impact on the environment and reflects the assessment of life.

The various components of quality of life—economic, environmental, social, mental, and political – are interconnected and influence one another (Figure 1). However, the strongest link exists between environmental and social factors, particularly health conditions, life expectancy, and mortality. For instance, according to World Health Organization (WHO) estimates, nearly a quarter of all global deaths are linked to environmental factors (WHO, 2022).

One of the most widely used indicators of life quality is mortality rate. It provides valuable insights into the health, living conditions, and socioeconomic development of the population (Aimbetova *et al.*, 2022; Liang *et al.*, 2023). High mortality rates often reflect inadequate healthcare access, poor nutrition, and the prevalence of diseases, all of which degrade quality of life. Lower mortality rates, on the other hand, are typically associated with better healthcare, improved sanitation, higher income levels, and enhanced education, signaling a higher standard of living. The analysis of various studies showed that a better quality of life is associated with a lower mortality risk (Phyo *et al.*, 2020). Environmental factors, such as pollution and access to clean water significantly impact mortality rates, serving as indicators of both environment conditions and overall living standards. As a standardized measure, mortality

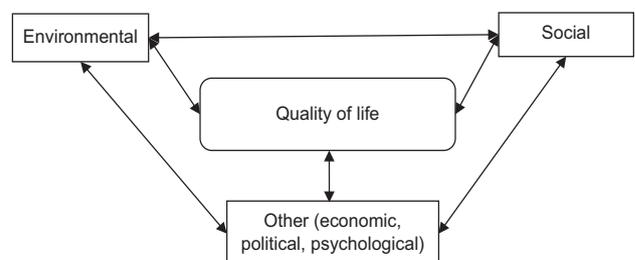


Figure 1. Main components of quality of life
Source: Authors' own representation.

rate facilitates comparisons across regions or countries, providing a consistent metric to assess how various factors influence life quality. While mortality rates are powerful indicators, they may not capture all aspects of quality of life, such as mental health, social well-being, or individual satisfaction. However, given these data are fully available for the period of the study, it is appropriate to use them in our analysis.

2. Data and methods

2.1. Data sources

The study drew on socioeconomic and environmental data from 2001 to 2020 to examine mortality trends in the Carpathian region of Ukraine. All data were obtained from the State Statistics Service of Ukraine, except for water pollution indicators, which were sourced from the State Agency of Water Resources of Ukraine. Mortality rates, a central variable, were calculated as the median rate across four oblasts – Zakarpattia, Ivano-Frankivsk, Lviv, and Chernivtsi. Socioeconomic indicators such as gross regional product (GRP) per capita and foreign direct investment (FDI) highlight economic conditions and investment dynamics. Environmental factors include emissions of air pollutants and discharge of contaminated water, both of which showed declining trends during the study period. In addition, government expenditures on environmental protection and healthcare provide insight into policy-driven efforts to mitigate negative environmental and health impacts. This combination of data allows for a comprehensive understanding of the factors influencing mortality in the region.

2.2. Methods

To study the impact of environmental and economic factors on the mortality rates in the Carpathian region as a whole, and in its constituent oblasts (Zakarpattia, Ivano-Frankivsk, Lviv, and Chernivtsi), we used regression analysis. The multiple regression and least squares methods are the standard mathematical and statistical instruments for assessing the relationships between these factors (Chen *et al.*, 2021; Huang *et al.*, 2020).

Multiple regression models are essential for analyzing complex relationships between socioeconomic, environmental, and health-related factors. They are particularly useful for extracting valuable insights from large datasets and mathematically modeling the relationships between independent and dependent variables. By understanding these relationships, researchers can predict the value of the dependent variable based on the known values of the independent variables. In the context of public health, mortality rates are influenced

by many variables, including environmental conditions, economic status, and social determinants. Therefore, applying multiple regression models offers a powerful approach to studying how these factors collectively impact mortality rates.

The ordinary least squares (OLS) method was chosen to estimate the model due to its simplicity, efficiency, and widespread applicability in regression analysis. OLS minimizes the sum of squared residuals, ensuring the best linear unbiased estimates under the Gauss–Markov assumptions, which include linearity, homoscedasticity, no autocorrelation, and the absence of perfect multicollinearity. OLS is particularly advantageous because it provides interpretable coefficients, which indicate the magnitude and direction of the impact of each independent variable on the dependent variable. In this study, OLS helps quantify how socioeconomic factors, such as GRP and FDI, alongside environmental indicators, such as pollutant emissions and public expenditures, influence mortality rates. Moreover, including differenced data and lagged variables allows for capturing temporal effects and delayed responses, adding depth to the analysis. Using this method, the research gains insights into the intricate dynamics between public health and its determinants, supporting evidence-based policymaking for regional development.

The basic model is as follows:

$$Y_t = a + \beta_1 GRP_t + \beta_2 FDIR_{t-1} + \beta_3 PolAir_t + \beta_4 PolWater_t + \beta_5 Env_t + \beta_6 Health_t + \mu \quad (1)$$

The dependent variable Y_t represents the mortality rate in the Carpathian region of Ukraine per thousand people at time t during the study period (2001 – 2020). It was calculated as the median mortality rate of the four oblasts of the Carpathian Region of Ukraine. Between 2001 and 2020, a slight decrease in mortality was observed in the region (Figure 2). The significant increase in 2020 can be attributed to the impact of the COVID-19 pandemic. The data were obtained from the State Statistics Service of Ukraine.

- GRP_t represents the GRP per capita in the Carpathian region. It helps determine the volume of the internal regional market and indicates the level of welfare in the region. Its effect on the dependent variable was expected to be negative.
- $FDIR_{t-1}$ refers to the amount of FDI in the region, with a 1-year lag. The lag indicator was used because some time must pass between the moment of investment and the commencement of active operations in polluting industries. The impact of FDI on the dependent variable was expected to be positive.

- $PolAir_t$ represents the emission of pollutants into the atmosphere in the Carpathian region, while $PolWater_t$ refers to the discharge of contaminated return water into the surface runoff in the region. Both indicators showed a declining trend during the research period (Figure 3), although at different rates. Both were expected to directly impact the dependent variable.
 - Env_t represents government expenditure on environmental protection in the Carpathian region. It allows for the indirect consideration of state environmental policy on public health. The coefficient for this indicator in the regression model was expected to be negative.
 - $Health$ refers to government expenditures on healthcare in the Carpathian region. As with the previous variable, the coefficient of this indicator in the regression model was expected to be negative.
 - μ represents the residual term.
- Differencing was applied to the variables to address potential non-stationarity issues and enhance the analytical robustness. This transformation ensures that the analysis captures changes over time rather than static levels, which may be influenced by broader structural factors unrelated to the study's scope.

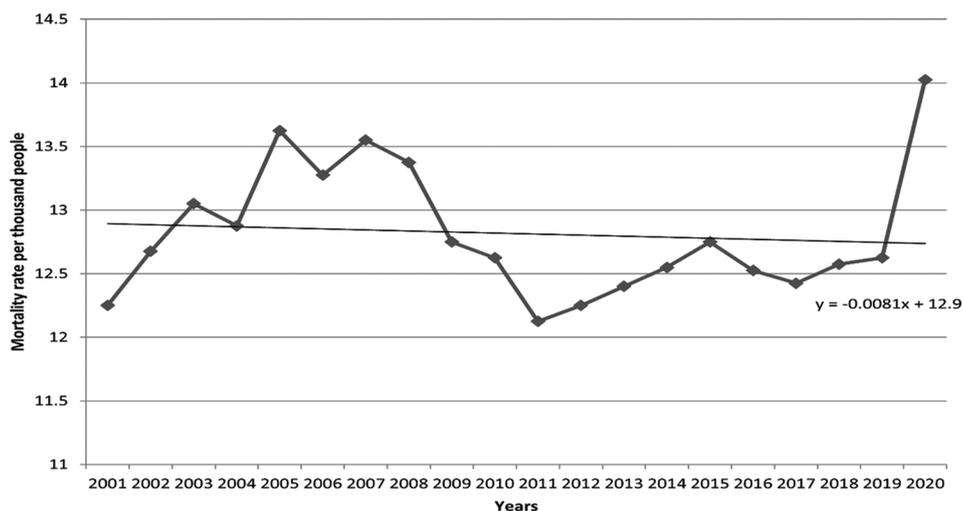


Figure 2. The mortality rate in the Carpathian region per 1,000 people
 Source: Authors' own representation based on data from the State Statistics Service of Ukraine.

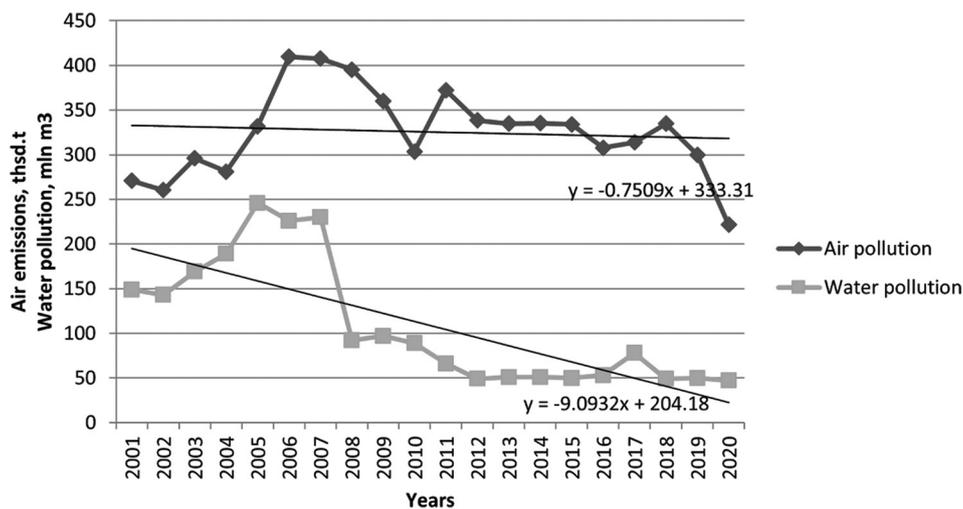


Figure 3. Emissions of pollutants into the atmosphere and surface waters in the Carpathian region, from 2001 to 2020
 Source: Authors' own representation based on the data from the State Statistics Service of Ukraine and the State Agency of Water Resources of Ukraine.

2.3. Operationalization of variables

Precise measures and operationalization of variables were employed to comprehensively analyze the factors influencing mortality rates in the Carpathian region. The dependent variable, “mortality rate,” represents the number of deaths per 1,000 individuals, calculated as the median rate across the region’s four constituent oblasts: Zakarpattia, Ivano-Frankivsk, Lviv, and Chernivtsi. This measure provides a standardized and reliable indicator of public health trends over the study period.

Independent variables were carefully chosen to capture the socioeconomic and environmental dimensions influencing mortality. GRP per capita serves as a proxy for regional economic prosperity, representing total economic output divided by the population. This variable highlights the overall economic welfare of the region and its potential impact on health outcomes. FDI, measured with a 1-year lag, reflects external economic activities and the possible introduction of industrial or polluting activities. The lagged values allow for the time required for investments to impact the region’s socioeconomic and environmental dynamics.

Environmental indicators include emissions of air pollutants (*PolAir*) and the discharge of contaminated water into surface runoff (*PolWater*). These variables were obtained from official government sources and are proxies for environmental quality and potential health risks. Both indicators are expressed in tons per year to standardize and facilitate comparisons across time. In addition, government expenditures on environmental protection (*Env*) and healthcare (*Health*) were included to account for policy interventions aimed at improving environmental conditions and public health. These variables were expressed in inflation-adjusted monetary units to reflect actual spending levels.

3. Results

Before proceeding directly to model analysis, it is important to examine the data for statistical problems. The biggest issue that can arise in this type of research is multicollinearity, which can distort the results. [Table 1](#) shows the correlation matrix of our variables. Multicollinearity is a concern when the correlation exceeds 0.8. However, no critical correlation values were observed between our variables. High (but not critical) correlations were noted between GRP per capita and FDI variables in the region, as well as GRP per capita and environmental spending.

We analyzed the model using the least squares method, which is the most commonly used approach for such models. The constructed regression equation is as follows:

$$Y_t = 11,153 - 0.005GRP_t + 0.004FDIR_{t-1} + 0.315PolAir_t + 0.893PolWater_t - 0.078Env_t + 0.017Health_t + 0.012 \quad (II)$$

To ensure the robustness of the regression analysis, a series of diagnostic tests were conducted to address potential statistical issues. Autocorrelation was evaluated using the Durbin–Watson statistic, which yielded values within acceptable ranges, indicating no significant autocorrelation in the residuals. Heteroscedasticity was tested using the Breusch–Pagan test, revealing no significant violations of homoscedasticity. This confirmed that the variance of residuals remains consistent across observations, satisfying one of the key assumptions of the OLS method.

The normality of residuals was assessed through graphical methods, such as Q-Q plots and the Shapiro–Wilk test. Both approaches confirmed that residuals align with normal distribution assumptions, ensuring the validity of statistical inferences drawn from the model. A correlation matrix was constructed to address potential multicollinearity ([Table 2](#)). None of the correlations between independent variables exceeded the critical threshold of 0.8, indicating no severe multicollinearity issues.

Table 1. Correlation matrix of variables of the econometric model determining the impact of environmental and socioeconomic factors on mortality in the Carpathian region

| Parameter | GRP _t | FDIR _{t-1} | PolAir _t | PolWater _t | Env _t | Health _t |
|-----------------------|------------------|---------------------|---------------------|-----------------------|------------------|---------------------|
| GRP _t | 1.0 | - | - | - | - | - |
| FDIR _{t-1} | 0.6 | 1.0 | - | - | - | - |
| PolAir _t | -0.3 | 0.01 | 1.0 | - | - | - |
| PolWater _t | -0.3 | 0.004 | 0.1 | 1.0 | - | - |
| Env _t | 0.6 | 0.05 | -0.4 | -0.4 | 1.0 | - |
| Health _t | 0.5 | 0.3 | 0.01 | 0.01 | 0.02 | 1.0 |

Source: Authors’ own calculations.

Abbreviations: *Env*: Government expenditure on environmental protection in the Carpathian region; *FDIR_{t-1}*: Amount of foreign direct investment in the region, with a 1-year lag; *GRP*: Gross regional product; *Health*: Government expenditures on healthcare in the Carpathian region; *PolAir_t*: Emission of pollutants into the atmosphere in the Carpathian region; *PolWater_t*: Discharge of contaminated return water into surface runoff in the region; *t*: Time.

Table 2. Diagnostic test results

| Diagnostic test | Result |
|-------------------------|--|
| Durbin–Watson statistic | 1.8314 |
| Breusch–Pagan test | 2.71 |
| Shapiro–Wilk test | 0.982776 |
| Multicollinearity check | Correlation values below 0.8 threshold |

Source: Authors’ own calculations.

Endogeneity concerns were addressed by incorporating lagged variables, such as FDI with a 1-year lag, to capture delayed effects and reduce simultaneity bias. In addition, differencing the data helped mitigate issues related to non-stationarity, further enhancing the model's reliability. These diagnostic checks and methodological adjustments ensure that the model's results are robust and credible, providing a strong foundation for analyzing the impact of socioeconomic and environmental factors on mortality rates.

These diagnostic test results underscore the rigor of the analytical framework and the attention given to addressing potential statistical and methodological issues. The Breusch–Pagan test for heteroscedasticity yielded a test statistic value of 2.71, which was compared to the Chi-squared critical value of 0.4378 at 6° of freedom. As the test statistic exceeds the critical value, there is weak evidence suggesting potential heteroscedasticity in the model.

The results of regression analysis for the general model are presented in Table 3.

An analysis of the 2001 – 2020 indicators for the Carpathian region reveals a strong correlation between improved socioeconomic conditions and reduced mortality rates, supporting the expectation that higher living standards contribute to better health outcomes. Specifically, the data indicate that as socioeconomic conditions improve, mortality rates decline, emphasizing the critical role of welfare in public health. Furthermore, the coefficients for variables related to water and air pollution,

as well as environmental protection, were statistically significant, indicating that these environmental factors play a critical role in influencing mortality. The signs of these coefficients support the hypothesis that higher pollution levels are associated with increased mortality, while stronger environmental protection efforts are linked to lower mortality rates. This reinforces the idea that economic welfare and environmental quality are essential in improving public health and reducing mortality in the region.

Notably, water pollution has more than twice the impact on mortality compared to air pollution. This result aligns with previous studies (Kjellstrom *et al.*, 2006), which demonstrate that air pollution contributes up to 0.6% of the disease burden in developing regions, while water pollution may contribute as much as 0.9%.

The indicator of foreign investment in the region was also statistically significant and showed a positive sign. This finding supports the hypothesis that foreign investments, particularly in industries that exploit the region's rich natural resources, often contribute to environmental pollution and, consequently, higher mortality rates. Meanwhile, the healthcare expenditure coefficient was positive but not statistically significant, suggesting that increased healthcare spending alone does not necessarily lead to improved health outcomes.

In addition, separate analyses of the same set of factors for each oblast in the Carpathian region were conducted. The results (Table 4) are largely consistent with the overall model, reinforcing the broader findings of this study.

Notable differences were observed in the coefficient for FDI in Ivano-Frankivska oblast. Unlike the other oblasts and the Carpathian region as a whole, FDI growth in this oblast was associated with a reduction in mortality rates, indicating a positive impact on the population's quality of life. This discrepancy may be attributed to the structure of foreign investments in the region and warrants further investigation. While most studies suggest that FDI inflows generally enhance life expectancy through direct and indirect channels (Aalipour *et al.*, 2023; Beşe & Kalayci, 2021), some evidence indicates that foreign investment can negatively affect public health and increase mortality, particularly in middle- and high-income countries (Chiappini *et al.*, 2022, pp. 24 – 26). This suggests that, while FDI generally promotes economic growth and improved living standards, it may also introduce adverse effects, such as environmental degradation or inequitable resource distribution.

The analysis of healthcare expenditures in Lvivska and Chernivetska oblasts reveals an unexpected trend: higher

Table 3. Impact of environmental and economic factors on mortality in the Carpathian region

| Variable | General model | Std | p-value |
|-----------------------|---------------|-------|---------|
| GRP _t | -0.005 | 0.00 | 0.001 |
| FDIR _{t-1} | 0.004 | 0.00 | 0.093 |
| PolAir _t | 0.315 | 0.01 | 0.033 |
| PolWater _t | 0.893 | 0.01 | 0.003 |
| Env _t | -0.078 | 0.01 | 0.045 |
| Health _t | 0.017 | 0.14 | 0.909 |
| Constant | 11.153 | 8.5 | 0.002 |
| R-squares | | 0.763 | |
| Observations | | 20 | |

Source: Authors' own calculations.

Abbreviations: *Env*: Government expenditure on environmental protection in the Carpathian region; *FDIR_{t-1}*: Amount of foreign direct investment in the region, with a 1-year lag; *GRP*: Gross regional product; *Health*: Government expenditures on healthcare in the Carpathian region; *PolAir_t*: Emission of pollutants into the atmosphere in the Carpathian region; *PolWater_t*: Discharge of contaminated return water into surface runoff in the region; *Std*: Standard deviation; *t*: Time.

Table 4. Impact of environmental and economic factors on mortality by oblast in the Carpathian region

| Oblast | Variable | Coefficients | Std | p-value |
|------------------|--------------|--------------|-------|---------|
| Zakarpatska | GRP_t | -0.014 | 0.00 | 0.071 |
| | $FDIR_{t-1}$ | 0.015 | 0.01 | 0.051 |
| | $PolAir_t$ | 0.043 | 0.02 | 0.073 |
| | $PolWater_t$ | 1.192 | 0.05 | 0.050 |
| | Env_t | -0.010 | 0.02 | 0.051 |
| | $Health_t$ | -0.922 | 0.55 | 0.115 |
| | Constant | 19.397 | 5.75 | 0.005 |
| | R-squares | | 0.704 | |
| | Observations | | 20 | |
| Ivano-Frankivska | GRP_t | -0.240 | 0.00 | 0.050 |
| | $FDIR_{t-1}$ | -0.067 | 0.00 | 0.011 |
| | $PolAir_t$ | 0.204 | 0.01 | 0.096 |
| | $PolWater_t$ | 2.056 | 0.02 | 0.002 |
| | Env_t | -0.090 | 0.00 | 0.050 |
| | $Health_t$ | -0.851 | 0.63 | 0.203 |
| | Constant | 25.038 | 9.01 | 0.016 |
| | R-squares | | 0.697 | |
| | Observations | | 20 | |
| Lvivska | GRP_t | 8.223 | 0.00 | 0.751 |
| | $FDIR_{t-1}$ | 0.002 | 0.00 | 0.006 |
| | $PolAir_t$ | 0.022 | 0.01 | 0.010 |
| | $PolWater_t$ | 0.518 | 0.02 | 0.008 |
| | Env_t | 3.456 | 0.00 | 0.342 |
| | $Health_t$ | 0.218 | 0.29 | 0.136 |
| | Constant | 9.102 | 7.39 | 0.240 |
| | R-squares | | 0.712 | |
| | Observations | | 20 | |
| Chernivetska | GRP_t | -0.673 | 0.00 | 0.096 |
| | $FDIR_{t-1}$ | -0.240 | 0.01 | 0.846 |
| | $PolAir_t$ | 0.427 | 0.34 | 0.023 |
| | $PolWater_t$ | 0.629 | 0.06 | 0.003 |
| | Env_t | -0.611 | 0.02 | 0.072 |
| | $Health_t$ | 0.812 | 0.49 | 0.261 |
| | Constant | 3.628 | 5.28 | 0.504 |
| | R-squares | | 0.740 | |
| | Observations | | 20 | |

Source: Authors' own calculations.

Abbreviations: *Env*: Government expenditure on environmental protection in the Carpathian region; *FDIR_{t-1}*: Amount of foreign direct investment in the region, with a 1-year lag; *GRP*: Gross regional product; *Health*: Government expenditures on healthcare in the Carpathian region; *PolAir*: Emission of pollutants into the atmosphere in the Carpathian region; *PolWater*: Discharge of contaminated return water into surface runoff in the region; *Std*: Standard deviation; *t*: Time.

healthcare spending correlates with increased mortality. However, this relationship was statistically significant only in Lvivska oblast, where the coefficient reached a significance of 10%. This counterintuitive finding may reflect inefficiencies in public fund allocation or systemic flaws in healthcare policies. Ineffective spending, lack of targeted interventions, and resource mismanagement could mean that increased investments in healthcare fail to yield meaningful improvements in health outcomes, as seen in Lvivska oblast.

The multiple regression model confirms several key hypotheses regarding the impact of environmental and economic factors on mortality rates in the Carpathian region. As expected, economic development and improved regional welfare were associated with lower mortality rates. Higher living standards typically lead to better access to healthcare, improved nutrition, and healthier living conditions, all of which contribute to increased life expectancy. Similarly, the analysis highlights the beneficial effects of increased environmental protection expenditures, indicating that investments in pollution reduction and natural resource conservation have a tangible positive impact on public health.

The findings underscore the harmful effects of environmental degradation, particularly water and air pollution, on mortality in the Carpathian region. While both types of pollution negatively impact public health, the data indicate that water pollution has a significantly stronger influence on mortality than air pollution. This may be due to the region's dependence on water sources for agriculture, drinking, and other essential needs, making water quality a critical determinant of health outcomes. Contaminated water can lead to various illnesses, including gastrointestinal diseases, which disproportionately affect vulnerable populations, such as children and the elderly.

The empirical data also supports the hypothesis that the Carpathian region has become a "haven for polluters" in the context of FDI. In both Zakarpatska and Lvivska oblasts, a direct correlation between FDI growth and increasing mortality rates was observed. This finding suggests that foreign investment may be linked to activities that harm the environment, such as industrial projects that prioritize profit over sustainable practices. As the Carpathian region borders many European Union members, foreign investment may often be directed to Ukraine to avoid stricter European environmental legislation (Levinson & Taylor, 2008; Tang, 2015; Duan *et al.*, 2021). It can be assumed that foreign investments in the Carpathian region are directed mainly to polluting enterprises, harming public health. Thus, Ukraine, with lenient environmental

regulation, is becoming a haven for polluters. The lack of stringent environmental regulations allows foreign investors to operate in ways that degrade natural resources and negatively impact public health. Official statistical data on FDI in Zakarpattia and Lviv highlight a concentration in manufacturing-related industries, particularly the automotive and machinery sectors (NBU, 2024). In Zakarpatska oblast, FDI often targets enterprises producing car components, leveraging the region's proximity to European markets and lower operational costs. Lviv attracts significant foreign investment in information technology and manufacturing, particularly in textiles and food processing, which align with the region's skilled workforce and infrastructure. Both regions also see foreign capital flowing into the energy and mining sectors, often associated with less stringent environmental regulations. This investment pattern underscores the dual impact of FDI, fostering economic growth while potentially increasing environmental and health-related challenges.

However, in Ivano-Frankivska oblast, a different pattern emerged: FDI growth was associated with a reduction in mortality, potentially due to a more sustainable structure of investments or different industrial profiles. This divergent result highlights the need for further research into how the specific nature and sectors of foreign investments shape health outcomes across different regions.

The results regarding healthcare expenditures were also mixed. While the hypothesis that increased healthcare spending reduces mortality was confirmed for Zakarpatska oblast, the opposite effect was observed in Lvivska oblast, likely due to the inefficacy of state health policies. In other oblasts, healthcare spending was not found to have a statistically significant impact on mortality. These findings underscore the complexity of public health dynamics, where simply increasing spending is not enough – effective allocation, proper management, and the design of targeted health interventions are crucial to ensuring that healthcare investments lead to tangible improvements in population health.

Thus, the regression analysis validated the hypotheses about the negative impact of water and air pollution on the population's quality of life in the Carpathian region. These variables led to increased mortality rates. At the same time, GRP per capita and expenditure on environmental measures for the region decreased mortality. In addition, foreign investments sometimes lead to increased mortality, which requires a more detailed study of their structure and indicates the need for improvements in regional investment policies. This challenges the assumption that all investments are beneficial and calls for a more nuanced approach to regional investment strategies.

4. Discussion

While the regression analysis provides valuable insights into the factors influencing mortality in the Carpathian region, several limitations must be acknowledged. The reliance on aggregated-level data for the four oblasts introduced the risk of ecological fallacy, where relationships observed at the group level may not accurately reflect individual-level dynamics. For example, variations within oblasts or among specific population subgroups may remain obscured, potentially leading to oversimplified conclusions. Median mortality rates and other aggregate measures may not capture short-term fluctuations or localized phenomena, such as disease outbreaks or environmental disasters.

Methodologically, while differencing and lagging variables address issues, such as non-stationarity and simultaneity bias, these techniques may also reduce the richness of the data by focusing solely on changes rather than absolute levels. Furthermore, while comprehensive, the selection of variables may exclude other relevant factors, such as behavioral, cultural, or institutional influences, which could play a critical role in shaping mortality outcomes.

Finally, the studies temporal scope (2001 – 2020) limits its applicability to ongoing developments, such as the long-term effects of the COVID-19 pandemic. As the pandemic significantly impacted mortality rates in 2020, caution is warranted when generalizing findings to future periods or attributing trends solely to the factors analyzed. Addressing these limitations in future research could involve incorporating micro-level data, exploring additional variables, and extending the temporal range to enhance the robustness and applicability of the findings.

As the analysis showed a negative impact of environmental problems on the quality of life of the population in the Carpathian region, ways to address these problems and overcome the environmental crisis must be found. One such solution is the implementation of policy measures consolidated within the Carpathian Eco-Way strategic initiative. The strategy framework stipulates the achievement of several major and interdependent objectives: preserving and restoring natural capital in the Carpathian region, ensuring the cleanliness of the air, water, and land, transitioning to a green economy, and developing an environmentally efficient behavior model for economic entities, residents, and visitors of the region (Figure 4).

4.1. Objective 1: Preservation of the natural capital of the Carpathians

The achievement of this objective requires the development and implementation of measures to protect and rehabilitate

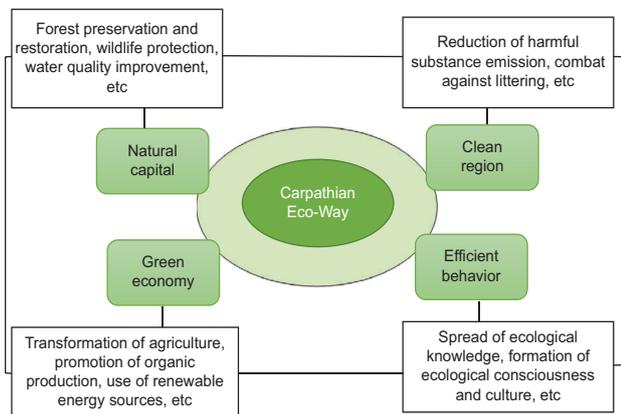


Figure 4. Elements and directions of the strategy for improving the environmental component of the quality of life in the Carpathian region of Ukraine.

Source: Authors' own elaboration.

forests, parks, and other green spaces. It is essential to recognize that forests are not only an important economic resource but also a habitat for 80% of terrestrial animals and plants. Humanity would not have survived without trees and forests, as they provide oxygen, food, wood, and other resources while absorbing carbon. Approximately one billion people globally depend on forest products (wild meat, edible insects, edible plant products, mushrooms, and fish) to some extent (FAO & UNEP, 2020, p. 19). Forests also contribute to physical and psychological health. Numerous studies demonstrate the positive impact of forest walks on cardiovascular and respiratory systems, immunity enhancement, and stress reduction. Therefore, the slogan “Healthy Forests Mean Healthy People,” used by many programs and initiatives in the last decade, is well-supported (Suzuki, 2020).

The problem of forest preservation and rehabilitation is particularly relevant for the Carpathian region of Ukraine, which faces significant threats and requires special attention and protection from the state. Indeed, over 2,000 unique plant species grow in this region, with relic species and endemics preserved, and its beech forests are included in the UNESCO World Heritage. Nevertheless, logging in the Carpathian mountaintops has increased threefold since 2001. According to experts, one-third part of the logging is illegal (Bezpiatchuk, 2020). Illegal logging in the Carpathian region caused Ukrainian hryvnia 18.3 million in damage to the state in 2020 and Ukrainian hryvnia 7.1 million in the first half of 2021 (Marchuk, 2021).

This highlights the urgent problem of combatting illegal logging in the Carpathian region and across Ukraine. Despite some measures taken by the government (such as the implementation of the Wood Electronic Accounting system), the situation with illegal logging remain largely

unchanged. The Carpathian region and Ukraine continue to lose forests – one of their most valuable resources – due to legislative gaps, overlapping control functions between the State Forestry Agency and the State Environmental Inspection, an inefficient judicial system, and high corruption levels within forestry. International expert commissions argue that an incorrectly constructed governance system in the forestry sector is a fundamental problem and a source of corruption (Ukraine Crisis Media Center, 2020). This fosters the emergence of various schemes. For instance, healthy wood is destroyed under the guise of sanitary felling and exported as firewood or timber. Logging beyond the designated areas is another common violation, with actual felling areas sometimes being twice as large as specified in the documentation. Moreover, trees within the reserve fund continue to be destroyed, and wood continues to be exported without the necessary documents.

Preservation of the forests in the Carpathian region requires an integrated approach and a solution to a range of problems across multiple levels. First and foremost, the governance system in forestry should be improved at the national level. In particular, economic, regulatory, and supervisory functions should be clearly delineated among the relevant public authorities. Coordination of activities and increased interaction between agencies are important to solving the tasks assigned to them and adequately responding to the main economic and social challenges.

The system of environmental control currently requires reform. Expanding the powers of the State Environmental Inspection (e.g., allowing it to immediately suspend logging rather than going through a judicial procedure) would enable an immediate response to violations. The ability to conduct unscheduled inspections, expand the range of people who can initiate them, and increase fines for impeding inspectors' work would strengthen environmental enforcement. Moreover, simplifying the procedure of proving violations to law enforcement agencies is necessary. The establishment of supervisory councils at the local level to monitor timber harvesting, transportation, and sales would strengthen the environmental control system in the forestry sector of the Carpathian region. To reduce shadow markets, these councils could cooperate with lumber mills and widely involve the community in their activities. The efficiency of such cooperation would benefit from the creation of specific mobile applications designed to immediately verify and report illegal logging. For example, Romania's “Inspectorul Padurii” application (Popescu, 2018) allows users to enter the registration number of a harvester. If the number is not found in the database, the harvester does not have an official permit to

transport timber and should be reported to the authorities. Moreover, increased responsibility through substantial fines for both loggers and consumers, as well as criminal liability for purchasing illegally harvested timber, could further reduce illegal logging.

It is worth emphasizing that deforestation in the Carpathian region has contributed to climate change, landslides, and, subsequently, frequent large-scale floods. For instance, in June 2020, 300 towns and villages were affected by floods, and 500 km of roads were damaged (Bratyuk, 2020). Therefore, reducing continuous felling and transitioning to sustainable methods of logging (e.g., selective cutting) is necessary. As forests are important for moisture retention on mountain slopes, the preservation of soils should be considered in the standards for logging.

The United Nations General Assembly has declared 2021 – 2030 as the Decade of Ecosystem Restoration, which provides an opportunity to support the large-scale restoration of degraded forest landscapes, increasing environmental sustainability and efficiency and contributing to the achievement of many Sustainable Development Goals. Some countries have already made commitments under the Bonn Challenge that aim to restore 350 million hectares of degraded and deforested landscapes by 2030, with Sustainable Development Goal 15.3 targeting land degradation neutrality by 2030. There are also regional initiatives, such as the Great Green Wall (a project led by the African Union to combat desertification in the south), the African Forest Landscape Restoration Initiative, Initiative 20 × 20 in Latin America, and ECCA30 in Europe, the Caucasus, and Central Asia (Wilkie, 2021).

In November 2021, at the Conference of the Parties 26 Climate Change Conference in Glasgow, 110 countries, representing 85% of the world's forests, signed the Declaration to preserve and regenerate forests (Ministry of Ecology and Natural Resources of Ukraine, 2021). Ukraine joined the Declaration and pledged to stop deforestation and initiate the restoration of forest cover by 2030.

Several presidential orders in Ukraine focus on nature and environmental preservation. For instance, Order No. 381/2017, "On Additional Measures on Forestry Development, Rational Nature Management, and Natural Reserve Fund Objects Preservation," and Order No. 511/2019, "On Some Measures on Forests Preservation and Rational Use of Forest Resources." The Green Country project, launched in June 2020 in Ukraine, aimed to significantly increase forested areas. Within this initiative, the Order of the President of Ukraine, "On Some Measures on Forests Preservation and Rehabilitation" (No. 228/2021 as of June 7, 2021), was issued to launch the environmental project titled "Large-Scale Reforestation of

Ukraine." Its implementation involves planting one billion new trees within 3 years. By late November 2021, about 38 million trees had been planted, including five million in the Carpathian region (Zelena, 2021).

However, reforestation is not just about planting trees. It involves restoring balance among the environmental, social, and economic benefits of forests and land use. In some cases, natural regeneration of local plants is the best approach, while in others, planting trees and vegetation can accelerate the recovery of health and productivity of degraded landscapes (Wilkie, 2021). The Great Green Wall is an example of the latter approach.

It is worth mentioning that illegal and mass deforestation is not the only issue contributing to drastic climate change and deteriorating quality of life. Illegal fishing, poaching of large carnivores, and the killing of wild birds also affect nature. For instance, according to environmentalists, 40 – 50 brown bears are illegally killed annually in the region, despite fewer than 200 remaining in the Carpathians (Malovanyi, 2020). The population of Romania plays a critical role in preventing their extinction. Therefore, the animal protection system should be strengthened by increasing accountability for lawbreakers, using advanced technologies (such as drones and mobile applications to record and report violations), and encouraging strong public involvement. Mineral and thermal waters are unique natural resources in the Carpathian region. To preserve them, the protection of sanitary zones around these resources should be reinforced, and excessive pumping should be prohibited, as it leads to contamination and depletion of the sources.

4.2. Objective 2: "Clean" region

The implementation of Objective 2 aims to reduce air and water pollution and address littering in the territory. The Carpathian region has the highest river density in Ukraine, surpassing other regions 4 – 7 times. However, the problem of quality drinking water remains pressing, as significant amounts of agrochemicals, wastewater, and industrial waste enter the region's reservoirs. The following measures are needed to address this problem: Rationalizing freshwater use; establishing water protection zones and coastal protection zones for water bodies; reconstructing existing centralized water supply and sewerage systems and creating new ones where necessary; and modernizing existing water treatment facilities and sewerage networks. To reduce industrial water pollution, it is essential to strengthen control over compliance with legislation and standards by economic entities, as well as increase penalties for violations.

The level of pollutant emissions into the atmosphere from stationary sources varied across the oblasts of the

region. Ivano-Frankivska and Lvivska oblasts were of particular concern. According to *Ivano-Frankivska Oblast Development Strategy 2021 – 2027*, Ivano-Frankivska oblast alone accounts for 11% of the country's total carbon dioxide emissions. The electricity, gas, water production and distribution, and mining sectors are significant contributors to pollution. For instance, VP "Burshtynska TES" of the AT "DTEK Zahidenerho" in Ivano-Frankivska oblast produces 83% of the total harmful substance emissions in the region. These companies need to modernize their filters, and in general, a transition to renewable energy sources is vital. In particular, the Energy Opportunities for Zakarpatska Oblast Communities project outlines three pilot models for autonomous energy provision from renewable sources in local communities, including the creation of micro-networks in mountain areas.

To address the problem of industrial and household waste and package accumulation, it is essential to support the international 3R initiative: Reduce waste production, reuse materials, and recycle. This includes establishing a separate collection and sorting system for household and packaging waste, improving waste treatment for both industrial and household waste, and improving the level of environmental awareness in the region.

4.3. Objective 3: Green regional economy

The green economy model promotes economic growth while ensuring environmental sustainability. According to United Nations environmentalists, a green economy enhances human well-being, reduces social inequality, mitigates environmental risks, and prevents depletion of resources (EaP Green, 2017, p. 9). Through the declarations signed in the Eastern Partnership framework, Ukraine has pledged to adhere to the principles of a green economy. This commitment calls for a radical transformation in natural resource management, industry, and societal attitudes. The agro-industrial sector is considered the most critical area in transitioning to a green economy, as it impacts various aspects of sustainable development.

4.4. Objective 4: Environmentally efficient behavior

Overcoming the environmental crisis depends on human activity, consciousness, and culture. Therefore, developing a behavior model that positively impacts the environment is necessary. Environmentally efficient behavior refers to a system of human actions and attitudes that preserves the environment and improves its condition (Figure 5).

On one hand, such behavior should be developed through the environmentalization of educational and training processes for people of all ages, active dissemination of information about the natural environment, and a

heightened awareness of anthropogenic impact (e.g., the negative consequences of illegal logging for both nature and people). On the other hand, strict environmental legislation and efficient enforcement mechanisms should be in place. Moreover, applying all types of punishment (administrative, disciplinary, and criminal) to economic entities and consumers is essential. This requires reforming the judicial system and combating corruption at all levels. Environmental discipline, which forms the basis of environmental conscience and culture, is developed depending on the value-needs structure of individuals, as well as environmental awareness and an understanding of the penalties for environmental offenses (such as compliance with environmental law, standards, and regulations, as well as timely fulfillment of obligations).

Environmental conscience reflects an entity's axiological position and attitude toward the natural environment. It is based on environmental awareness, an understanding of one's responsibility to the environment, the need to preserve nature, and the ways to address environmental problems. Environmental culture is developed based on environmental knowledge and conscience, forming a new paradigm of human thinking and eco-centric behavior norms. It is built on the harmony and cohesion of humans and the environment, rather than their opposition.

Individuals simultaneously play various societal roles, so human behavior can be divided into three groups, each defining the main activity peculiar to each group. As an economic entity, an individual should comply with environmental law, switch to renewable energy sources, treat waste, switch to organic products and eco-packaging, etc.

Consumers who engage in environmentally friendly behavior are essential to solving environmental problems. They conserve water, gas, and energy, minimize their use of paper, disposable tableware, and plastic bags, and purchase eco-friendly and certified wood products.

We believe that the development of environmentally friendly behavior can only be achieved through the symbiosis of informational and regulatory mechanisms. Their effectiveness depends, in part, on human characteristics. Indeed, the interaction between these mechanisms can lead to environmentally neutral or justified human behavior. Environmentally friendly behavior is not only based on environmental awareness and discipline but also on intrinsic motivation and an active human position. Environmentally friendly behavior is not only based on environmental awareness and discipline but also on intrinsic motivation and an active human position (for example, support and participation in environmental initiatives). Environmental volunteering

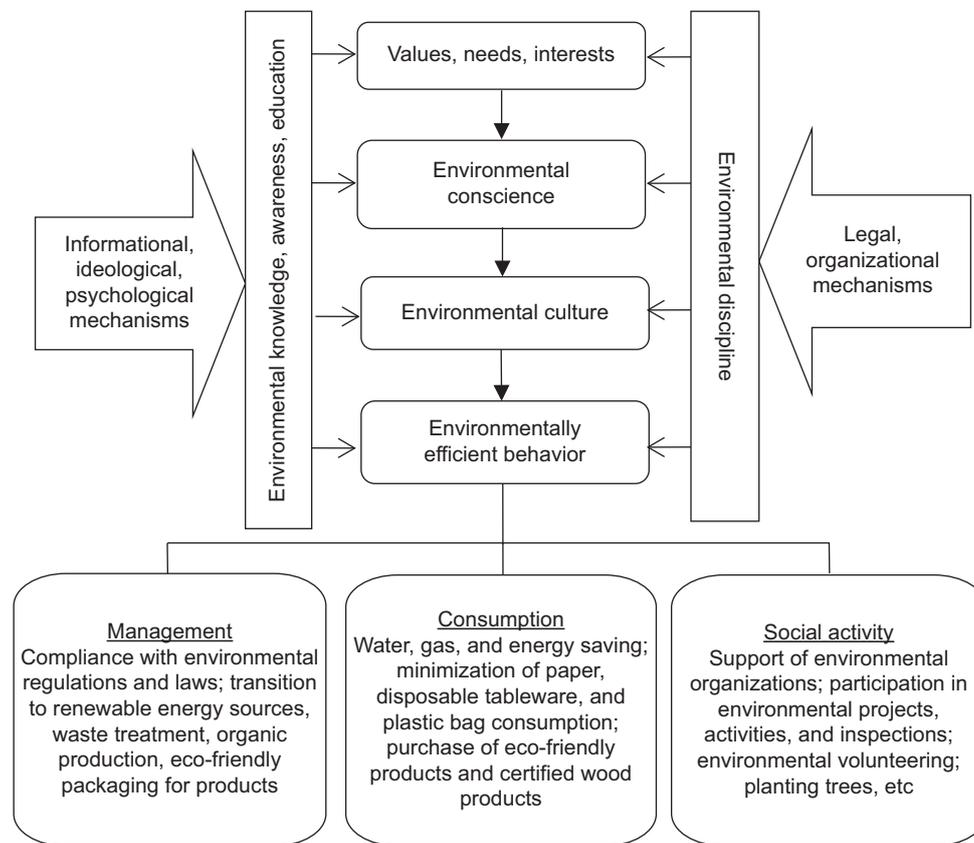


Figure 5. Model of developing environmentally efficient behavior
Source: Authors' own elaboration.

is another important aspect, mainly focused on cleaning areas such as roads or roadways. Local inspections of illegal logging, as well as pollution of water, air, and soil, and efforts to combat illicit dumping, are essential in the Carpathian region.

5. Conclusion

Quality of life is a comprehensive concept that encompasses different aspects of human functioning, which can be difficult to cover in a single study. Therefore, this paper focused on the environmental component – one of the most urgent and insufficiently addressed problems. As the regression analysis showed, environmental factors have a negative impact on the population's quality of life in the Carpathian region. In response, the Carpathian Eco-Way Strategy was presented, aimed at overcoming the environmental crisis and enhancing the environmental component of the quality of life in the Carpathian region of Ukraine. The strategy outlines the achievement of the following interdependent objectives: The preservation and restoration of the natural capital in the Carpathian region, ensuring the cleanliness of air, water, and land, transitioning to a green economy, and developing a model of environmentally efficient behavior

for economic entities, residents, and visitors of the region. A range of priority tasks is set within each objective. The success of achieving the first three goals is grounded in the environmentally friendly behavior of the population, defined as a system of human actions and attitudes directed at preserving and improving the environment. This research provides a model for developing environmentally efficient behavior that highlights the interaction between external mechanisms (legal and informational) and individual socio-psychological characteristics. It also outlines the main features of environmentally efficient behavior for individuals as economic entities, consumers, and members of society.

The study offers a new perspective on how to foster sustainable practices among various stakeholders in the region. This interdisciplinary approach provides valuable insights for policymakers, environmentalists, and economists alike. Further research should focus on specific methods and ways to address pollution in the water, soil, and air in the Carpathian region.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

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Methodology: Olha Ryndzak

Writing – original draft: Olha Ryndzak

Writing – review & editing: Lilia Ukrainets, Iryna Gerlach

Ethics approval and consent to participate

Not applicable.

Consent for publication

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Availability of data

The data used in the study were obtained from the open databases of the State Statistics Service of Ukraine and the State Agency of Water Resources of Ukraine.

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