



КООПЕРАЦИЯ НАУКИ И ОБЩЕСТВА КАК ИНСТРУМЕНТ МОДЕРНИЗАЦИИ И ИННОВАЦИОННОГО РАЗВИТИЯ

**Сборник статей
Международной научно-практической конференции
10 июля 2025 г.**

АЭТЕРНА
УФА
2025

2. Cai S.J., Yang P. Tailings problems and tailings utilization and treatments in the metal mines. Eng Sci. 2000. Vol. 2. No. 4. P. 89 -.
3. Wang S., Xue K.X., Lv L., Zhang D., Li D. Review of Research on Physical and Mechanical Properties and Engineering Application of Metal Tailings. Journal of Physics: Conference Series. 2022. Vol. 2148 No. 1. P. 012059 -.
4. Wang S., Zhao Y., Li S., Wei Z. Improvement of Traditional Mining Tailings Storage Facilities. Journal of Residuals Science & Technology. 2016. Vol. 13. No. 4.
5. Maltrana V., Morales J. The Use of Acid Leaching to Recover Metals from Tailings: A Review. Superalloys. Metals. 2023. Vol. 13. No. 11. P. 1862 -.
6. Zhao J., Wei Z., Yang Y., Lu T., Wang W., Li S.L. Control of dust from tailings pond using conventional halides and polymer materials[J]. Chinese Journal of Engineering. 2021. Vol. 43. No. 4. P. 486 - 494.
7. Long H., Zhu D., Pan J., Li S., Yang C.C., Guo Z., Xu X. A critical review on metallurgical recovery of iron from iron ore tailings. Journal of Environmental Chemical Engineering. 2024. Vol. 12. No. 2. P. 112140 -.
8. He J., Chen J., Wu Q., He G., Ying P. Study on Process Mineralogy of a Certain Copper Tailing. China Mining. 2014. Vol. 10. P. 121 - 124.

© Nguyen Thi Hong, Vu Thi Lan Anh, Dao Trung Thanh, 2025

УДК 52

Phan Thi Mai Hoa

Graduate University of Science and Technology,
Vietnam Academy of Science and Technology,
Hanoi, Vietnam

Nguyen Thi Cuc

Hanoi University of Mining and Geology,
Hanoi, Vietnam

Scientific supervisor: Nguyen Quoc Phi

Hanoi University of Mining and Geology,
Hanoi, Vietnam

ASSESSING SPATIAL COUPLING OF LANDSLIDE HAZARD AND SOCIAL SENSITIVITY: A CASE STUDY IN HA QUANG DISTRICT, VIETNAM

Abstract

Ha Quang District, Cao Bang Province, Vietnam, faces substantial landslide risks due to steep topography, intense monsoonal rainfall, and complex geological structures. The district's predominantly ethnic minority population, reliant primarily on subsistence farming, encounters significant socioeconomic vulnerabilities, intensifying their susceptibility to environmental hazards. This research establishes a comprehensive vulnerability assessment model by integrating geographic information systems (GIS) with Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods, alongside validation through Ordinary Least Squares (OLS) regression with Newey - West adjustments. Our results highlight that communes including Cai Vien and Ha Thon exhibit notably high combined

vulnerability indices, driven by the synergistic interactions between social and geophysical factors. Conversely, areas such as Luong Thong, Da Thong, and Xuan Hoa display resilience primarily due to favorable demographic structures and relatively stable environmental conditions. These insights facilitate strategic resource allocation and proactive disaster risk reduction policies in landslide - prone regions.

Key words: Ha Quang, SVI, GIS, AHP, TOPSIS, OLS

1. Background

Social vulnerability refers to the capacity of communities to withstand, cope with, and recover from natural disasters. In mountainous regions such as Ha Quang District, Cao Bang Province, Vietnam, landslides represent an ongoing hazard due to complex topographical features, intense monsoonal rainfall, and fragile geological conditions. The district's demographic composition, primarily ethnic minority groups like Tay, Nung, and H'Mong, relying mainly on subsistence agriculture, significantly exacerbates socioeconomic vulnerabilities and disaster susceptibility. Addressing these multidimensional challenges requires a comprehensive approach integrating socio - economic factors with geospatial analysis.

Recent research underscores the efficacy of combining social vulnerability indices with advanced geospatial and statistical methods to enhance the precision and effectiveness of disaster management frameworks. Notably, the incorporation of machine learning and high - resolution remote sensing has provided marked improvements in predictive accuracy and real - time vulnerability assessments ([4], [10], [9], [11]).

Compared to traditional methods, the integration of Geographic Information Systems (GIS), Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and statistical validation using Multiple Linear Regression (MLR) with Newey - West adjusted regression employed in this study offers robust methodological advantages. Specifically, the combination of AHP and TOPSIS enables an objective weighting and ranking of vulnerability factors through systematic expert judgments, overcoming limitations of purely subjective or overly simplistic analytical approaches. Further, the MLR with Newey - West adjustment provides rigorous statistical validation, effectively addressing issues such as heteroscedasticity and autocorrelation common in spatial analyses, thus ensuring reliability and accuracy in the results.

2. Study area

Ha Quang District, located in the northern part of Cao Bang Province, Vietnam, encompasses an area of approximately 810.96 km² and had a population of 59,467 inhabitants as of 2019, resulting in an average density of 73 individuals per square kilometer [3]. Characterized by rugged mountainous terrain, steep slopes, and deep valleys, the district is highly susceptible to landslide events, especially during the intense monsoon season. Additionally, the district's socio - economic landscape, dominated by ethnic minority communities engaged predominantly in subsistence agriculture, exacerbates their vulnerability due to limited economic opportunities, infrastructure inadequacies, and restricted access to essential services.

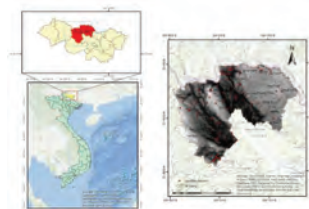


Figure 1. Study area in Ha Quang, Cao Bang Province

3. Methodology

3.1. Data source

In line with the research objectives, the evaluation index system incorporates both environmental and socioeconomic variables. Environmental factors related to landslide risks, including elevation (DEM), slope gradient, and proximity to rivers and streams, were derived from recent topographic maps and Landsat 8 (OLI+) satellite imagery provided by USGS in December 2023. Vegetation coverage was assessed using the Normalized Difference Vegetation Index (NDVI), calculated following Rouse et al. (1973). NDVI is a normalized index with a value between - 1.0 and 1.0. Additionally, soil moisture and average rainfall data were obtained from rainfall maps for September 2023. Socioeconomic indicators, including population density, birth rate, elderly population ratio, ethnic minority ratio, and working - age population ratio, were collected from sociological surveys conducted in Cao Bang province in 2019, based on methodologies outlined by Frigerio et al. (2016).

3.2. Analysis method

This study employs an integrated methodological approach to examine the interaction between environmental and socio - economic factors when assessing landslide - related vulnerability in Ha Quang district. By combining landslide hazard analysis and social vulnerability assessment.

a) Landslide hazard analysis

In this research, seven key geographical factors influencing landslide occurrence were systematically analyzed utilizing Geographic Information Systems (GIS) combined with remote sensing methods to construct a robust Landslide Susceptibility Index (LSI). Initially, spatial data corresponding to each selected factor were acquired, standardized, and preprocessed to ensure comparability. Subsequently, the Analytical Hierarchy Process (AHP) [12] was employed to determine the relative importance of each factor through expert judgment. Specifically, a pairwise comparison matrix was formulated based on assessments from a panel of six subject matter experts, which facilitated the calculation of factor - specific weights. The consistency and reliability of these judgments were verified through the calculation of a consistency ratio (CR), ensuring that the weight allocations were robust and methodologically sound. Finally, the weighted factors were integrated using a composite index, providing a comprehensive spatial representation of landslide hazard across the study area.

The CR assesses the consistency of the judgments in the PCM. It is calculated as:

$$CR = \frac{CI}{RI} \quad (1)$$

where the **Consistency Index (CI)** is:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (2)$$

with $\lambda_{\max}$ denoting the maximum eigenvalue obtained from the pairwise comparison matrix (PCM), and RI represents the Random Consistency Index, which varies according to matrix dimensions as indicated in Table 2. A consistency ratio (CR) of less than 0.1 confirms that the assigned weights have acceptable internal consistency and reliability.

Table 2. The RI value

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,52	0,89	1,11	1,25	1,35	1,40	1,45	1,49

b) Social Vulnerability Analysis

The basic framework for calculating the SVI can be outlined as follows:

$$SVI = \sum_{i=1}^n W_i x_i \quad (3)$$

Where:

- X_i is the value of each component variable in the index.
- W_i is the weight applied to that variable, representing the relative importance of each factor in assessing social vulnerability.
- n is the total number of component variables used in the SVI.

The index comprises essential factors influencing community susceptibility to natural disasters as listed in Table 1. To quantify these factors systematically, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), a multi - criteria decision - making method, was employed.

TOPSIS evaluates and ranks alternatives by measuring their relative distances from the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS). The procedure involves normalization of the initial decision matrix to standardize data for comparability. Integrating the resulting Social Vulnerability Index (SVI) with landslide susceptibility maps allowed precise identification of high - priority areas requiring targeted disaster mitigation interventions. The normalization is performed using:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_i^n x_{ij}^2}} \quad (4)$$

Where: x_{ij} is the value for criterion j of region i and r_{ij} is the normalized value.

Each criterion is assigned a weight w_j based on expert judgment, ensuring the importance of different factors is reflected. The weighted normalized value is then computed as:

$$v_{ij} = w_j \times r_{ij} \quad (5)$$

• **Positive ideal Solution (A^+)** represents the best possible values for each beneficial criterion and the lowest values for non - beneficial ones:

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\} \quad (6)$$

• **Negative Ideal Solution (A^-)** represents the worst values for beneficial criteria and highest values for non - beneficial ones:

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} \quad (7)$$

Each alternative's separation from PIS and NIS is computed using the Euclidean distance formula:

$$S_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^+)^2} \quad (8)$$

$$S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2} \quad (9)$$

The **relative closeness (C_i)** of each alternative to the ideal solution is determined as:

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad (10)$$

The relative closeness coefficient (CI) ranges from 0 to 1, with higher values indicating greater proximity to the ideal solution. Accordingly, regions with the highest CI scores are considered the least socially vulnerable, whereas those with the lowest scores exhibit the greatest vulnerability.

To capture the combined effect of physical and social dimensions, the Landslide Susceptibility Index (LSI) and Social Vulnerability Index (SVI) were integrated through a GIS - based weighted

overlay analysis, resulting in the Landslide Risk Vulnerability Index (LRVI)—a comprehensive indicator for identifying high - risk areas requiring urgent attention.

c. Validation of landslide - induced vulnerability using Ordinary Least Squares (OLS) Analysis

To improve the reliability of statistical inferences in assessing landslide - induced vulnerability, the Newey - West standard error correction method was employed to address heteroscedasticity and autocorrelation in the regression model. The analysis began with estimating a conventional Ordinary Least Squares (OLS) regression model, formulated as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon \quad (12)$$

Where Y represents the Landslide Risk Vulnerability Index (LRVI), $X_1, X_2, \dots, X_n$ are the explanatory variables, and ε is the model error.

To diagnose statistical issues, autocorrelation was assessed using the Durbin - Watson test while heteroscedasticity was evaluated through the Breusch - Pagan test. When evidence of heteroscedasticity or serial correlation was detected, the Newey - West covariance matrix was applied to obtain heteroscedasticity - and autocorrelation - consistent (HAC) standard errors [7]. The adjusted variance - covariance estimator is defined as:

$$\hat{\Omega} = \sum_{t=1}^T e_t^2 + 2 \sum_{j=1}^q w(j, q) \sum_{t=j+1}^T e_t e_{t-j} \quad (13)$$

Where e_t represents the regression residuals, q is the maximum lag order (typically chosen as **1 or 4**) and $w(j, q)$ is a kernel weighting function to account for the influence of past observations [13].

Following the application of Newey - West standard errors, the model was reassessed by re - evaluating P - values, confidence intervals, and residual diagnostics, confirming the robustness of the corrections. This approach ensures that the regression model accurately captures the impact of both geographical and socio - economic factors in landslide vulnerability assessment while mitigating statistical distortions caused by autocorrelation and heteroscedasticity.

4. Results

4.1. Analysis of landslide risk factors

Figure 2 presents a radar chart illustrating the relative weight distribution of landslide - related factors derived from the Analytic Hierarchy Process (AHP). The chart clearly highlights that slope (SL) and rainfall (RF) possess the highest weights (34 and 33, respectively), indicating their dominant influence on landslide susceptibility within the study area. These findings align with the geomorphological and climatological context of Ha Quang, where steep terrain and intense monsoonal precipitation are primary triggering mechanisms.

Soil moisture (SM) holds a moderate weight, suggesting its secondary yet non - negligible contribution, particularly in areas where saturation influences slope stability. In contrast, river distance (RD), vegetation cover (NDVI), and elevation (DM) exhibit lower weights, implying a comparatively limited role in this specific terrain configuration.

Using the AHP method, normalized weights were calculated with a consistency ratio of 0.060, confirming reliable expert judgments. The resulting landslide susceptibility map classifies Ha Quang District into low, moderate, and high - risk zones (Fig.3). High - risk areas are mainly located in the north, such as Cai Vien, Van An, and Truong Ha, due to steep slopes, heavy rainfall, and sparse vegetation. Central regions show moderate risk, while the southern and western parts exhibit low susceptibility, benefiting from stable terrain, dense vegetation, and lower precipitation.



Figure 2. Normalized pair - wise comparison and weight values.
(SL slope, DM Dem, SM Soil moisture, RF rainfall, RD river density, NDVI)

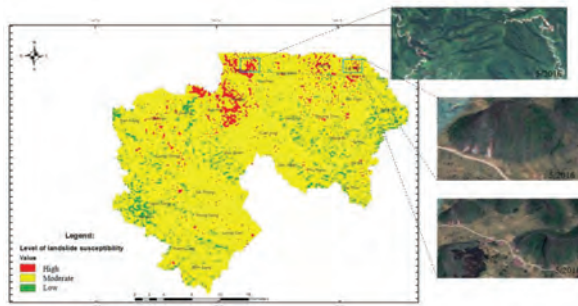


Figure 3. Building Landslide susceptibility Map Using AHP

4.2. Comprehensive analysis of social vulnerability

As shown in Figure 4, communes such as Xuan Hoa ($CI=0.988$), Luong Thong (0.784), and Da Thong (0.665) exhibit the highest CI scores, reflecting favorable socio - demographic characteristics and improved access to infrastructure. This interpretation is further supported by their lower PIS values and higher NIS scores, as presented in the PIS and NIS comparison chart (Fig.6), which together signify enhanced resilience and stronger adaptive capacity in the face of landslide hazards.

In contrast, Ha Thon (0.005), and Cai Vien (0.093) exhibit the lowest C_i values, highlighting critical vulnerability due to their aging populations, low education levels, and limited social services. The high PIS and low NIS values observed in these communes, as illustrated in the corresponding comparison chart, further substantiate their identification as critical areas requiring prioritized support and intervention measures (Fig.6).

The chart illustrates the distribution of communes in Ha Quang District across five levels of social vulnerability, based on the relative closeness coefficient (CI) derived from the TOPSIS method (Fig.5). The results reveal that a significant number of communes (16 out of 30) fall into the “Very High Vulnerability” category, indicating an urgent need for targeted support and intervention. An additional 7 communes are classified as “High Vulnerability,” reflecting considerable social risk. In contrast, only a few communes belong to the “Moderate” and “Low Vulnerability” groups, suggesting an uneven distribution of resilience across the district. Notably, just one commune is categorized under “Very Low Vulnerability,” indicating exceptionally

Community Type	Relative Frequency (%)
KHAM NGA	0.98
LUONG THONG	0.85
PHU NGOC	0.75
THUNG HOANG	0.65
SY MA	0.55
CAN VEH	0.48
GIA THONG	0.42
DAM NGAM	0.42
THONG COT	0.42
THUNG THON	0.38
NGOC CONG	0.35
CAN NGOC	0.32
THUNG LAO	0.32
MA BA	0.32
HONG SY	0.32
THAM LUONG	0.32
KEO PHU	0.32
DAI CHAU	0.32
MA SAC	0.32
CAN VEH	0.32
VAN SON	0.32
VAN AN	0.32
SOC LA	0.32
WUONG	0.32
DA THON	0.32

Vulnerability Level	Number of Companies
Very Low Vulnerability	1
Low Vulnerability	4
Moderate Vulnerability	2
High Vulnerability	7
Very High Vulnerability	16

Bar chart showing the proportion of PIS (blue bars) and NIS (orange bars) for 14 Vietnamese cities. The Y-axis represents the proportion from 0 to 0.5. The X-axis lists the cities. The legend indicates that blue represents PIS and orange represents NIS.

City	PIS	NIS
Cai Vien	0.42	0.18
Ha Thon	0.48	0.02
keo Yen	0.42	0.02
Ma Ba	0.42	0.02
Nol Thon	0.38	0.02
Nol Thon	0.38	0.02
Quy Quan	0.42	0.32
Sy Hai	0.02	0.28
Tong Cot	0.32	0.02
Van An	0.42	0.02
Xuan Hoa	0.42	0.48
Can Nong	0.38	0.02
Da Thong	0.28	0.32
Luong Thong	0.38	0.42
Thanh Long	0.42	0.02
Vi Quang	0.42	0.32

The Newey - West Adjusted Regression analysis confirms that landslide - induced vulnerability in the study area is governed by a complex interplay between geographical and socio - economic factors (Tab.2), each exerting distinct levels of influence (Fig.6).

index	Coef.	Std.Err.	t Stat	P - value	Lower 95 %	Upper 95 %
DEM	3.99E -05	7.69E -06	5.190	2.24E -07	2.48E -05	5.50E -05
Rainfall	3.62E -05	6.85E -06	5.286	1.34E -07	2.28E -05	4.96E -05
SM	-2.16E -03	5.20E -03	-0.415	6.78E -01	-1.24E -02	8.04E -03
NDVI	2.10E -03	5.20E -03	0.404	6.86E -01	-8.09E -03	1.23E -02
RD	2.39E -06	4.50E -07	5.320	1.12E -07	1.51E -06	3.28E -06
Population density	1.04E -04	1.62E -05	6.438	1.00E -10	7.23E -05	1.36E -04
Ethnic minority rate	-4.10E -05	5.68E -06	-7.198	1.40E -09	-5.20E -05	-2.97E -05
Birth rate	1.02E -03	1.47E -04	6.933	3.50E -09	7.29E -04	1.30E -03
Elderly rate	5.83E -05	2.07E -05	2.818	4.83E -03	1.77E -05	9.89E -05
Literacy rates,	7.38E -05	1.06E -05	6.977	2.90E -09	5.30E -05	9.45E -05
Working – age population ratio	3.79E -05	5.50E -06	6.902	4.80E -09	2.72E -05	4.87E -05
LRVI lag1	6.40E -01	5.22E -02	12.261	1.24E -10	5.37E -01	7.42E -01

The findings at Tab.2 and Fig.6 indicate that among the natural determinants, elevation (DEM) and rainfall are the most statistically significant contributors to vulnerability, with P - values $< 10^{-7}$, highlighting their dominant role in landslide susceptibility. This aligns with established geophysical theories, where higher elevations are commonly associated with steep slopes, increasing the propensity for mass movement under intense precipitation conditions. Additionally, proximity to river systems (RD) emerges as another crucial factor (P - value $\approx 10^{-7}$), emphasizing that areas near river networks are more prone to landslides, potentially due to increased fluvial erosion and hydrological destabilization of soil structures.

In the socio - economic domain, population density exhibits a high level of statistical significance (P - value $\approx 2.75 \times 10^{-7}$), underscoring the degree of human exposure to landslide hazards. Areas with high population concentrations, particularly those characterized by a significant proportion of ethnic minority communities (P - value $\approx 1.40 \times 10^{-9}$), experience greater vulnerability. This trend may be attributed to disparities in housing stability, land - use planning, and access to disaster mitigation infrastructure, which often remain inadequate in marginalized regions.

Furthermore, the birth ratio (P - value $\approx 3.50 \times 10^{-9}$) and literacy rate (P - value $\approx 2.90 \times 10^{-9}$) exert substantial influence on vulnerability levels. These results emphasize the role of community awareness, education, and social resilience in mitigating disaster impacts. Lower literacy levels are associated with reduced preparedness and limited accessibility to early warning systems, heightening overall vulnerability. Conversely, the working - age population ratio (P - value $\approx 4.80 \times 10^{-9}$) is positively correlated with resilience, suggesting that regions with a higher proportion of economically active individuals demonstrate greater post - disaster recovery potential.

A particularly noteworthy discovery is the significant impact of lagged landslide vulnerability (LRVI _ lag1, P - value = 1.24×10^{-12}), which exhibits a strong autocorrelation coefficient of 0.6397. This finding underscores the persistence of landslide vulnerability over time, where past occurrences strongly influence present risk levels. Such a phenomenon highlights the necessity for long - term mitigation measures, rather than relying solely on short - term reactive interventions after each landslide event.

Interestingly, certain variables, such as soil moisture (SM, P - value = 0.6783) and vegetation index (NDVI, P - value = 0.6864), fail to exhibit statistical significance within the model. This suggests that in the specific context of this study area, these factors do not play a predominant role in landslide vulnerability assessment, possibly due to variations in soil composition, vegetation coverage, or other site - specific geological conditions.

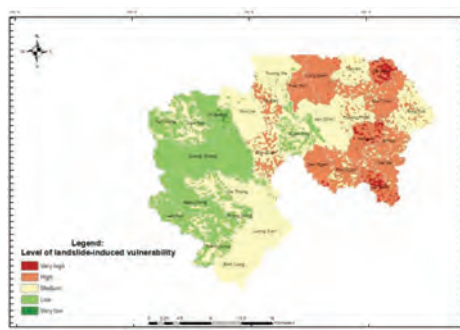


Figure 7. Composite Vulnerability Map for Landslide Risk Management in Ha Quang District, Cao Bang

5. Discussion

This study introduces a novel framework integrating GIS, AHP, TOPSIS, and Newey–West adjusted OLS regression to assess landslide vulnerability by combining geophysical and socio-economic factors. Unlike traditional single - method approaches, this integrated model enhances interpretability and precision by systematically weighting environmental factors (via AHP) and ranking social vulnerability indicators (via TOPSIS), followed by statistical validation of influencing variables using robust regression techniques [1], [5].

Compared to global studies employing machine learning or PCA based indices, this method ensures transparency and policy relevance through explicit factor ranking and risk quantification. While ML models offer high predictive performance, their black box nature limits practical interpretation [6]. Moreover, the spatial vulnerability patterns identified here are consistent with international findings: areas with higher poverty and minority populations tend to coincide with greater landslide exposure.

The resulting risk maps enable targeted interventions in communes like Cai Vien and Ha Thon, supporting evidence - based disaster planning (Fig.7). Policymakers can leverage this model to simulate “what - if” development scenarios and prioritize investments in education, infrastructure, or early warning systems.

Nonetheless, limitations exist. The reliance on expert judgment and commune - level data introduces subjectivity and spatial generalization. Future research should incorporate higher - resolution, dynamic, and participatory data, spatial regression models, and machine learning techniques to refine predictions and enhance local applicability. Overall, this framework offers a replicable, scalable tool for integrated disaster risk management in mountainous, socially vulnerable regions of Vietnam and beyond.

6. Conclusion

This study proposed an integrated framework combining GIS - based analysis, AHP–TOPSIS multi - criteria evaluation, and Newey–West adjusted OLS regression to assess landslide vulnerability in Ha Quang District, Vietnam. The results highlight the compounding effect of geophysical and socio - economic factors on overall risk levels.

The AHP model identified slope and rainfall as key contributors to landslide susceptibility, while TOPSIS results showed communes such as Cai Vien and Ha Thon as socially vulnerable due to high ethnic minority rates and low literacy. In contrast, Xuan Hoa and Luong Thong showed higher resilience.

Statistical validation using Newey–West adjusted OLS confirmed the significance of demographic variables such as population density, birth rate, literacy, and working - age ratio ($p < 0.01$), while ethnic minority rate had a significant negative impact on resilience. The inclusion of the lagged LRVI term further enhanced model robustness.

The key novelty lies in demonstrating how integrating AHP, TOPSIS, and adjusted regression better captures vulnerability interactions than isolated methods. This approach enables more precise spatial targeting for disaster risk reduction, especially in areas where social fragility coincides with environmental exposure. Future work should expand this model using machine learning and participatory GIS to improve predictive accuracy and policy relevance.

Acknowledgements: This research was funded by the Master, PhD Scholarship Programme of Vingroup Innovation Foundation (VINIF), code VINIF.2024.TS.109. We would like to thank the

anonymous reviewers for their valuable comments, which significantly enhanced the quality of this publication.

References

1. An, Y., Tan, X., Gu, B., & Zhu, K. (2020). Flood risk assessment using the CV - TOPSIS method for the Belt and Road Initiative: An empirical study of Southeast Asia. *Ecosystem Health and Sustainability*, 6(1), 1765703.
2. Frigerio, I. et al, 2016. A GIS - based approach to identify the spatial variability of social vulnerability to seismic hazard in Italy. *Applied Geography* 74 (2016) 12 - 22. <http://daneshyari.com/article/preview/83108.pdf>.
3. General Statistics Office. Online available: <https://www.gso.gov.vn/>.
4. Kavzoglu, T., Colkesen, I., & Sahin, E. K. (2019). Machine learning techniques in landslide susceptibility mapping: a survey and a case study. *Landslides: Theory, practice and modelling*, 283 - 301.
5. Liu, X., Shao, S., & Shao, S. (2024). Landslide susceptibility zonation using the analytical hierarchy process (AHP) in the Great Xi'an Region, China. *Scientific reports*, 14(1), 2941.
6. Ma, Z., Mei, G., & Piccialli, F. (2021). Machine learning for landslides prevention: a survey. *Neural Computing and Applications*, 33(17), 10881 - 10907.
7. Newey, W. K., & West, K. D. (1987). A simple, positive semi - definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica: Journal of the Econometric Society*, 55(3), 703 - 708.
8. Rouse, J. W., Jr., Haas, R. H., Deering, D. W., Schell, J. A., 1973. Monitoring the vernal advancement and retrogradation (green wave effect) of natural vegetation: Progress Report RSC 1978 - 2. Available online: <http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19740004927.pdf>.
9. Romshoo, S. A., Amin, M., Sastry, K. L. N., & Parmar, M. (2020). Integration of social, economic and environmental factors in GIS for land degradation vulnerability assessment in the Pir Panjal Himalaya, Kashmir, India. *Applied Geography*, 125, 102307.
10. Saha, S., Roy, J., Hembram, T. K., Pradhan, B., Dikshit, A., Abdul Maulud, K. N., & Alamri, A. M. (2021). Comparison between deep learning and tree - based machine learning approaches for landslide susceptibility mapping. *Water*, 13(19), 2664.
11. Shafian, S. A., & Hu, D. (2024). Integrating Machine Learning and Remote Sensing in Disaster Management: A Decadal Review of Post - Disaster Building Damage Assessment. *Buildings*, 14 (8).
12. Saaty, T. L. (1980). *The analytic hierarchy process*. McGraw - Hill.
13. Stock, J. H., & Watson, M. W. (2012). *Introduction to Econometrics* (3rd ed.). Pearson Education.

© Phan Thi Mai Hoa, Nguyen Thi Cuc, 2025

СОДЕРЖАНИЕ

ФИЗИКО-МАТЕМАТИЧЕСКИЕ НАУКИ

Гаврюшина Л.К. ВЛИЯНИЕ ЗВУКА НА ОРГАНИЗМ ЧЕЛОВЕКА	5
--	---

Дурыгина В. В., Кривша Н. С., Тетрашвили Е. В. МАТЕМАТИЧЕСКИЙ КВЕСТ - ИГРА ОТКРЫТИЙ ДЛЯ СОВРЕМЕННОГО СТУДЕНТА	6
---	---

ТЕХНИЧЕСКИЕ НАУКИ

Бесхмельнов М.И. ИНТЕНСИФИКАЦИЯ АЛГОРИТМОВ РОЕВОГО ИНТЕЛЛЕКТА: МЕТОДЫ И БИОИНСПИРИРОВАННЫЕ МОДЕЛИ	12
---	----

Зыбко П.А. ИННОВАЦИОННЫЕ ТЕХНОЛОГИИ В SMM	14
--	----

Мохна Е. А., Петрикова Е. В., Попова М. Ю. ИНЖЕНЕРНО - ТЕХНИЧЕСКОЕ ТВОРЧЕСТВО КАК ИНСТРУМЕНТ РАЗВИТИЯ ПОЗНАВАТЕЛЬНОЙ АКТИВНОСТИ ДЕТЕЙ	16
---	----

Хуттунен В.П. ОБЗОР АППАРАТНОГО И ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ, ПРИМЕНЯЕМОГО ДЛЯ АВТОМАТИЧЕСКОГО УПРАВЛЕНИЯ БПЛА	20
--	----

ИСТОРИЧЕСКИЕ НАУКИ

Акопджанова А.А. СУДЬБА ВЫПУСКНИКОВ МЕДИЦИНСКИХ ВУЗОВ В ГОДЫ ВЕЛИКОЙ ОТЕЧЕСТВЕННОЙ ВОЙНЫ	24
--	----

ЭКОНОМИЧЕСКИЕ НАУКИ

Гафиятуллин М.И. СОВЕРШЕНСТВОВАНИЕ СТРАТЕГИИ ЭКОНОМИЧЕСКОГО РАЗВИТИЯ ВЕРТИКАЛЬНО - ИНТЕГРИРОВАННЫХ НЕФТЯНЫХ КОМПАНИЙ	28
--	----

Зыбко П.А. МАРКЕТИНГ В СОЦИАЛЬНЫХ СЕТЯХ: ИСПОЛЬЗОВАНИЕ, ПРОБЛЕМЫ И ИХ РЕШЕНИЯ	32
---	----

Исомов Б.С. МЕТОДИКА ИНВЕСТИЦИОННОЙ ОЦЕНКИ «ЗЕЛЕННЫХ» ПРОЕКТОВ: ФИНАНСОВЫЕ, ЭКОЛОГИЧЕСКИЕ И СОЦИАЛЬНЫЕ АСПЕКТЫ	34
--	----

Колесина Ю.М. МЕТОДЫ И ПОКАЗАТЕЛИ ОЦЕНКИ КАЧЕСТВА ТОРГОВЫХ УСЛУГ И ТОРГОВОГО ОБСЛУЖИВАНИЯ	41
---	----

Лаврухин А. М., Новичков И. П., Колесина Ю. М.
ОСОБЕННОСТИ УПРАВЛЕНИЯ ЛОГИСТИКОЙ ИНТЕРНЕТ – МАГАЗИНА 46

Мухина Н.А.
РАЗРАБОТКА И ВНЕДРЕНИЕ СТРАТЕГИЧЕСКИХ
УПРАВЛЕНЧЕСКИХ РЕШЕНИЙ НА ПРЕДПРИЯТИИ
НА ОСНОВЕ АНАЛИЗА АСПЕКТОВ ВНЕШНЕЙ СРЕДЫ 52

ФИЛОЛОГИЧЕСКИЕ НАУКИ

Арзымбетова С. А.
ЛИНГВОКУЛЬТУРНЫЕ ФАКТОРЫ И СЕМАНТИЧЕСКИЕ СДВИГИ
ПРИ ПЕРЕВОДЕ ФРАЗЕОЛОГИЧЕСКИХ ЕДИНИЦ 58

Сапарниязова Д. Е.
ЯЗЫК, КУЛЬТУРА И ИДИОМЫ: ЛИНГВОКУЛЬТУРНЫЙ ПОДХОД
К ФРАЗЕОЛОГИЧЕСКИМ ЕДИНИЦАМ 60

Старова А.Д.
ЭРГОНИМЫ ТЕАТРОВ И КИНОТЕАТРОВ ЛОНДОНА
КАК ОТРАЖЕНИЕ КУЛЬТУРЫ ВЕЛИКОБРИТАНИИ 63

ЮРИДИЧЕСКИЕ НАУКИ

Громова Н. С.
ИНФОРМАЦИОННАЯ БЕЗОПАСНОСТЬ:
НАЦИОНАЛЬНЫЕ И ЛИЧНЫЕ УГРОЗЫ 68

Осташова Е. И.
ОСОБЕННОСТИ ПРАВОПРИМЕНИТЕЛЬНОЙ ПРАКТИКИ
ПОСЛЕДСТВИЙ НЕДЕЙСТВИТЕЛЬНОСТИ СДЕЛКИ
(В РАЗРЕЗЕ ГОСУДАРСТВЕННЫХ И МУНИЦИПАЛЬНЫХ ЗАКУПОК 70

Севеников И. И.
СУЩНОСТЬ И СОДЕРЖАНИЕ ДОГОВОРА В ГРАЖДАНСКОМ ПРАВЕ 76

Смирнов Д. В., Читаева А. Х.
КРИМИНАЛИСТИЧЕСКИЙ АНАЛИЗ МЕХАНИЗМОВ НЕЗАКОННОГО
ВЫВОДА КАПИТАЛА С ИСПОЛЬЗОВАНИЕМ ПОДЛОЖНЫХ ДОКУМЕНТОВ 79

Сорокина Н.П.
ПРОЦЕССУАЛЬНЫЕ ОСОБЕННОСТИ РАССМОТРЕНИЯ СООБЩЕНИЙ
О СОВЕРШЕНИИ ДЕТОУБИЙСТВА 90

Ульянов И. И.
ПРИНЦИПЫ ВНУТРЕННЕГО АУДИТА В ХОЛДИНГАХ 93

ПЕДАГОГИЧЕСКИЕ НАУКИ

Архипова М.С., Дыбошина Е.А.
ИМИТАЦИИ КАК СРЕДСТВО ОБУЧЕНИЯ РЕБЕНКА С АУТИЗМОМ 97

Волгарева И.А. ОЦЕНКА ДОСТИЖЕНИЙ В ДОПОЛНИТЕЛЬНОМ ОБРАЗОВАНИИ: НЕСТАНДАРТНЫЕ ПОДХОДЫ К МОНИТОРИНГУ ПРОГРЕССА И МОТИВАЦИИ УЧАЩИХСЯ	99
Горин А.С. АНАЛИЗ БАЗОВОЙ КОНЦЕПЦИИ ВИЗУАЛЬНОЙ ГРАМОТНОСТИ В КОНТЕКСТЕ СОВРЕМЕННОГО ОБЩЕСТВА	102
Данильченко Е.В., Котова А.И. СКАЗОЧНЫЕ ЛАБИРИНТЫ: «ИГРЫ В ФИОЛЕТОВОМ ЛЕСУ» И ИХ ВЛИЯНИЕ НА РАЗВИТИЕ ПОЗНАВАТЕЛЬНЫХ ПРОЦЕССОВ ДОШКОЛЬНИКОВ	105
Данильченко Е.В., Котова А.И. РАЗВИТИЕ ИНТЕЛЛЕКТУАЛЬНО - ТВОРЧЕСКОГО ПОТЕНЦИАЛА РЕБЕНКА С ПОМОЩЬЮ СЮЖЕТНО - ОБРАЗНЫХ ИГР ВОСКОБОВИЧА	106
Денисенко С.В., Лихошерстов А.В., Стародубцев Е. И. ИСПОЛЬЗОВАНИЕ НЕТРАДИЦИОННЫХ МЕТОДОВ И ТЕХНОЛОГИЙ В ФИЗКУЛЬТУРНО – ОЗДОРОВИТЕЛЬНОЙ РАБОТЕ ДОУ	108
Джаватова Г.Р. ФОРМИРОВАНИЕ ПРОФЕССИОНАЛЬНОЙ КОМПЕТЕНТНОСТИ РУКОВОДИТЕЛЯ В УПРАВЛЕНИИ ОБРАЗОВАТЕЛЬНОЙ ОРГАНИЗАЦИЕЙ	111
Звездникова А.С., Толмачёва А.Р., Медведева Н.Д. ИННОВАЦИОННЫЕ ПОДХОДЫ В ДЕЯТЕЛЬНОСТИ ЮИД: ОПЫТ И ПЕРСПЕКТИВЫ	115
Иванов В.П. СОВРЕМЕННЫЕ ПОДХОДЫ К ОРГАНИЗАЦИИ ЭКЗАМЕНАЦИОННОГО ПРОЦЕСС	116
Иванов В.П. МЕТОДИЧЕСКИЕ РЕКОМЕНДАЦИИ ПО РАБОТЕ С ИНОСТРАННЫМИ ОБУЧАЮЩИМИСЯ	118
Кравченко М.А., Гостищева О.Г., Чебанюк Е.И. ИННОВАЦИОННАЯ ДЕЯТЕЛЬНОСТЬ В СИСТЕМЕ ДОПОЛНИТЕЛЬНОГО ОБРАЗОВАНИЯ	120
Ломовцев И. Д. РЕАБИЛИТАЦИОННЫЕ МЕРОПРИЯТИЯ ДЛЯ ВОЗВРАЩЕНИЯ ВОЛЬНИКОВ В СПОРТИВНУЮ БОРЬБУ ПОСЛЕ АУТОПЛАСТИКИ ПЕРЕДНЕЙ КРЕСТООБРАЗНОЙ СВЯЗКИ	122
Мамыга К.А., Котягина К.В. ПАТРИОТИЧЕСКОЕ ВОСПИТАНИЕ МЛАДШИХ ШКОЛЬНИКОВ КАК ПЕДАГОГИЧЕСКАЯ ПРОБЛЕМА	126

Михайлусенко С.С., Войло О.Б.
ПРОФОРИЕНТИРОВАНИЕ ДОШКОЛЬНИКА
ПОСРЕДСТВОМ ВЗАИМОДЕЙСТВИЯ СЕМЬИ И ДОО 129

Мустафакулова Д.И.
ФАКТОРЫ, РАЗВИВАЮЩИЕ СИСТЕМНОЕ МЫШЛЕНИЕ
БУДУЩИХ УЧИТЕЛЕЙ БИОЛОГИИ И ЕГО СТРУКТУРНЫЕ КОМПОНЕНТЫ 133

Недосекова Е.В.
СТРАТЕГИИ ЭФФЕКТИВНОЙ ПОДГОТОВКИ СЕМИКЛАССНИКОВ
К ВПР ПО АНГЛИЙСКОМУ ЯЗЫКУ:
СОВРЕМЕННЫЕ ПОДХОДЫ И МЕТОДИЧЕСКИЕ РЕШЕНИЯ 135

Рыбинская Д.С., Киселева Е. А., Смелая А. С.
КОРРЕКЦИЯ ЗВУКОПРОИЗНОШЕНИЯ У МЛАДШИХ ШКОЛЬНИКОВ 137

Семенова Е.В.
ИНТЕГРАТИВНЫЕ СТРАТЕГИИ УНИВЕРСИТЕТОВ
КАК ФАКТОР ИННОВАЦИОННОГО РАЗВИТИЯ В КОНТЕКСТЕ
ВЗАИМОДЕЙСТВИЯ НАУКИ, ОБРАЗОВАНИЯ И ОБЩЕСТВА 139

Середа О.Ю., Сазонова А.С., Головенко С.К.
РАБОТА С РОДИТЕЛЯМИ В ДОУ СОГЛАСНО ФОП ДО 144

Тарханов Г.В., Бессарабов С.Д.
ПЕДАГОГИЧЕСКИЕ УСЛОВИЯ ФОРМИРОВАНИЯ
СТРЕССОУСТОЙЧИВОСТИ КУРСАНТОВ ВОЕННЫХ ВУЗОВ 146

Чечетин Д.А., Бондаренко А.Е., Дрозд Е.А.
МЫШЕЧНО - СУСТАВНАЯ ГИМНАСТИКА В КОРРЕКЦИИ
ПЛОСКОСТОПИЯ У ДЕТЕЙ СРЕДНЕГО ШКОЛЬНОГО ВОЗРАСТА 148

ПСИХОЛОГИЧЕСКИЕ НАУКИ

Тарханов Г.В., Быкасов А.А.
МЕТОДИКА ФОРМИРОВАНИЯ ЭМОЦИОНАЛЬНОЙ СТАБИЛЬНОСТИ
У ВОЕННОСЛУЖАЩИХ В УСЛОВИЯХ БОЕВОЙ ПОДГОТОВКИ 153

НАУКИ О ЗЕМЛЕ

Dao Trung Thanh, Nguyen Quoc Phi, Nguyen Thi Hong
GEOCHEMICAL ASSESSMENT AND SPATIAL DISTRIBUTION
OF HEAVY METALS IN COASTAL
SEDIMENTS AROUND CAI BAU ISLAND,
BAI TU LONG BAY, NORTHERN VIETNAM 156

Nguyen Thi Hoa
ASSESSING THE CURRENT ENVIRONMENTAL STATUS
AND DETERMINING THE CAUSES OF ENVIRONMENTAL POLLUTION
IN MINERAL EXPLOITATION ACTIVITIES IN COASTAL AREA
OF DUC THO, CAN LOC, HA TINH PROVINCE 164

Nguyen Thi Hong, Vu Thi Lan Anh, Dao Trung Thanh TAILINGS MANAGEMENT SOLUTION FOR COPPER MINING PROJECT IN SUOI THAU - PHIN NGAN CHAI AREA, LAO CAI PROVINCE	174
Phan Thi Mai Hoa, Nguyen Thi Cuc ASSESSING SPATIAL COUPLING OF LANDSLIDE HAZARD AND SOCIAL SENSITIVITY: A CASE STUDY IN HA QUANG DISTRICT, VIETNAM	180

**Международные и
Всероссийские научно-
практические
конференции**

По итогам конференции авторам предоставляется бесплатно в электронном виде:

- сборник статей научной конференции,
- индивидуальный сертификат участника,
- благодарность научному руководителю (при наличии).

Сборнику присваиваются индексы УДК, ББК и ISBN. В приложении к сборнику будут размещены приказ о проведении конференции и акт с результатами ее проведения.

Сборник будет размещен в открытом доступе в разделе "[Архив конференций](#)" (в течение 3 дней) и в научной библиотеке elibrary.ru (в течение 15 дней) по договору 242-02/2014К от 7 февраля 2014г.

Стоимость публикации 100 руб. за 1 страницу.
Минимальный объем-3 страницы

С графиком актуальных конференций Вы можете ознакомиться на сайте <https://aeterna-ufa.ru/akt-conf>

**Междисциплинарный
международный
научный журнал
«Инновационная наука»**

ISSN 2410-6070 (print)

Свидетельство о
регистрации
СМИ – ПИ №ФС77-61597

Журнал представлен в Ulrich's Periodicals Directory.
Все статьи индексируются системой Google Scholar.
Размещение в "КиберЛенинке" по договору №32505-01
Размещение в Научной библиотеке elibrary.ru по договору №103-02/2015

**Периодичность: 2 раза в месяц.
Прием материалов до 3 и 18 числа каждого месяца
Формат: Печатный журнал формата А4**

Стоимость публикации – 150 руб. за страницу
Минимальный объем статьи – 3 страницы

Размещение электронной версии журнала: в течение 5 рабочих дней
Рассылка авторских экземпляров: в течение 7 рабочих дней

Подробная информация о журнале <https://aeterna-ufa.ru/events/in>

Размещение в Научной библиотеке elibrary.ru по договору №103-02/2015

**Междисциплинарный
научный электронный
журнал «Академическая
публицистика»**

ISSN 2541-8076 (electron)

**Периодичность: 2 раза в месяц.
Прием материалов до 8 и 23 числа каждого месяца
Формат: Электронный научный журнал**

Стоимость публикации – 120 руб. за страницу
Минимальный объем статьи – 3 страницы

Размещение электронной версии на сайте: в течение 5 рабочих дней

Подробная информация о журнале <https://aeterna-ufa.ru/events/ap>

Научное издательство

Мы оказываем издательские услуги по публикации: авторских и коллективных монографий, учебных и научно-методических пособий, методических указаний, сборников статей, материалов и тезисов научных, технических и научно-практических конференций.

Издательские услуги включают в себя полный цикл полиграфического производства, который начинается с предварительного расчета оптимального варианта стоимости тиража и заканчивается доставкой готового тиража.

Научное издание

КООПЕРАЦИЯ НАУКИ И ОБЩЕСТВА КАК ИНСТРУМЕНТ МОДЕРНИЗАЦИИ И ИННОВАЦИОННОГО РАЗВИТИЯ

**Сборник статей
Международной научно-практической конференции
10 июля 2025 г.**

В авторской редакции
Издательство не несет ответственности за опубликованные материалы.
Все материалы отображают персональную позицию авторов.
Мнение Издательства может не совпадать с мнением авторов

Подписано в печать 11.07.2025 г. Формат 60х90/16.
Печать: цифровая. Гарнитура: Times New Roman
Усл. печ. л. 11,40. Тираж 500. Заказ 2433.



Отпечатано в редакционно-издательском отделе
НАУЧНО-ИЗДАТЕЛЬСКОГО ЦЕНТРА «АЭТЕРНА»
450076, г. Уфа, ул. Пушкина 120

<https://aeterna-ufa.ru>
info@aeterna-ufa.ru
+7 (347) 266 60 68