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Managing Resources Based on Influential Indicators for Sustainable Economic Development: A Case Study in Serbia

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Abstract: The balance between resource consumption and the ability of natural systems to meet the needs of future generations emerges as a prerequisite of sustainability. Sustainability means aligning economic growth and development with the interest of the environment and social development. Decision-making is a significant responsibility in an environment and the business world because decisions affect the ecology and business performance. It is necessary to adopt new approaches in decision-making to find an appropriate method for assessing and setting priority goals. Various methods for multi-criteria decision-making have been developed, including the Analytic Hierarchy Process (AHP). The paper deals with the management of natural and human resources for the sustainable economic development of Serbia by selecting influential factors, relying on a multi-criteria decision-making framework. Appropriate methods have been applied: AHP and several fuzzy AHP (FAHP) approaches. These methods' application enables the analysis of results from different aspects of expert opinion. Through a case study, this paper investigates the AHP method from several facets in which the identification of decision criteria is based on the perception of experts of different profiles. The findings of this research can be a guideline for decision-makers in resource management to enhance sustainable economic development. The case study confirms that the stability of the business environment and business sectors is the most influential indicator in all scenarios.

Keywords: managing; economic development; resources; analytic hierarchy process (AHP); fuzzy AHP

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1. Introduction and Literature Review

The sustainable economic development of each state is conditioned primarily by natural (but also human) potentials, which are usually the backbone of the development of the region and the state [1]. Using these potentials while shaping them according to needs, people have survived and developed concerning economic and overall progress. At the same time, technical-technological development and especially the development of ICT has certainly improved everyday life and work without which it is impossible to imagine a modern way of functioning of people and economy, but it has also led to faster exploitation of the human environment, faster depletion of available natural resources [2]. Natural resources are a baseline for development and wealth creation. There is a possibility that the natural regeneration of resources can't keep pace with industry progress. The enrichment of human potential can have a technological impact on increasing the contribution of natural resources to economic growth [3].

Serbia is a territorially small country, but it has quality natural and human resources. The best promotion of socially, environmentally, and economically sustainable growth is an issue that is increasingly at the center of interest [4]. In economic terms, Serbia has characterized by developed regions in the north and underdeveloped ones in the south. The basic premise of profitable and overall socio-economic development is balanced economic prosperity [5]. The management of natural and human resources and the implementation of sustainable development have imposed the need to pay more attention to profit-making aspects in the future [6,7]. Excessive exploitation of natural resources creates many interrelated problems that affect the health of ecosystems and social well-being in different regions.

The starting point is that further economic growth has based on resources' smart exploitation [8,9]. The development of the Serbian economy in a sustainable direction can look only on achieving economic growth, primarily knowledge-based, information, people, education, and the quality of connections between people and institutions [10]. Sustainable economic development is needed based on the growth of a group of key economic indicators (GDP growth, employment, foreign trade, competitiveness and exports, investment, household standards) with a reduction in the solvent burden of external debt, as well as achieving lasting macroeconomic stability, the better quality of life, ecological condition and general well-being of society [11].

The population creates significant pressure on the capital, whose area is constantly expanding and prevents the balanced development of other cities and regions in the country. The challenges of Serbia's spatial development are, among other things, a consequence of the late transition [12]. The key to the transition period was the privatization of state property with the return to a market-oriented economy. These have been mostly affected the economy due to reduced budget inflows, job losses, and shortages in the manufacturing sector. Some municipalities have already made progress in creating a stimulating business climate, and some have yet to work hard and intensively to realize their potential.

Lately, there has often been talking of a knowledge-based economy. The European Union, with Lisbon Strategy, and Serbia, with Sustainable Development Strategy, plan further economic development through an economy that bases economic prosperity 3 on education and knowledge [13].

The new phase of social processes is facing the public consciousness of citizens with the problem of determining the additional path of development, given that there is a need to review the accumulated experience and the appropriate transformation of the economic management system towards sustainable development. In a systematic approach to the sustainable development of the country as a whole, and especially the underdeveloped regions of Serbia, elements such as the state, society, people with their knowledge and skills, economy, ICT, ecology are precisely those elements that need to be included and viewed in a complex way [14]. Namely, these elements have been combined in the institutional sense known as a public-private partnership (PPP). It is necessary to develop new efficient decision-making models to improve the quality of social life. Through these models, one can create an economically sustainable development strategy, anticipate possible risk events, and minimize them in innovative PPP projects [15].

The naturally available wealth and human resources are the backbones of sustainable economic development [16]. Excessive exploitation of natural resources creates many interrelated problems that affect the health of ecosystems and social well-being in different regions.

The region's sustainable economic development strategy includes the planned development achievements definition [17]. The region's economy is an unfavorable economic structure with weak financial, natural, and technological resources and needs sustainable restructuring with an increase in gross domestic product, development of foreign trade, employment rate, investment, and competitiveness on the international market [18]. To use all the potential, serious work, strong leadership, and a clear vision have been necessary [19]. Strong leadership, setting investments as priorities for municipal activities, with focused work and energy can make a difference, as shown by the examples of some successful municipalities [20].

The strategic management in regional economic development should enable a timely and rational response of the region's economy to all changes in the economic environs in which the region's entities operate [21]. It is necessary to implement pre-planned steps such as analysis of the economic environment, the economic orientation of the district, formulation of the plan of economic development, implementation of the defined strategy, and implementation of strategic control [22].

The paper contains five sections. The introduction provides elementary remarks on the subject area in the framework of managing natural and human resources for the sustainable economic development of the region and literature review. The Section 2 provides the conceptual framework. The methodology, which consists of AHP, and fuzzy triangular AHP methods, is given in the Section 3. After them in this section, indicators are chosen within four different groups. Section 4 part presents the ranking results and comparison of the results of the given algorithms with the discussion. Concluding remarks and future research goals have been presented in the last Section 5.

2. Conceptual Framework

One of the basic concepts of the economics of natural resources and the environment is the concept of sustainable development. Despite the different interpretations that can be found in the literature, this concept today has a central place in considering the long-term perspective of the survival and progress of human race in aligning economic growth and development with the interests of environmental protection and social development.

The research process adopted in this paper is realized as Figure 1 shows.

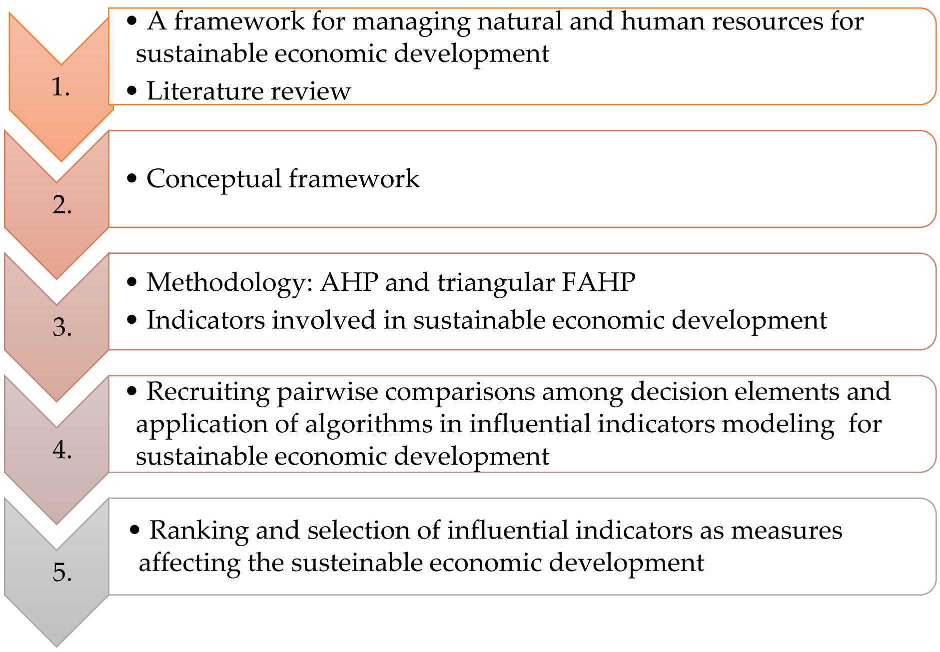

Figure 1. Five steps in the research process.

The paper presents the factors that influence the managing natural and human resources for the economic development of Serbia through four groups (a framework for strengthening participation in the development, human social resources, economic potentials, and natural resources). Modeling a framework for supporting participation and managing resources in the sustainable economic development of Serbia is considered in this research from the aspect of crisp AHP and fuzzy approaches of method AHP to single out influential factors. Managers show interest in creating and implementing reliable modus for decision-making in the present and the future. Achieving sustainable development requires developing an appropriate strategy to achieve sustainable development by applying maintenance performance measurements [23]. The method Analytic Hierarchy Process (AHP) was introduced by Thomas L. Saati in 1980 [24,25]. It is a method for solving multi-criteria decision-making (MCDM) problems. After a comprehensive evaluation of several criteria, it points to the final choice of the best solution in the analyzed problem [26]. The AHP method is widely used, despite the need for consistency testing, primarily because of its flexibility and ease of use [27]. Many methods and applications of fuzzy AHP are expressed by numerous researchers [28,29]. In applying the Fuzzy Analytic Hierarchy Process (FAHP) method, we used Chang's Extent analysis method (EAM) approach and the three-level optimism approach [30,31]. The results obtained by explained methods are compared with the results given by Interval AHP (IAHP) as in the paper [28].

More details about MCDM methods can be seen in the papers [32–34].

The goal is to single out influential factors obtained by methods application and compare the results. The task of the paper is to compare the extent to which these approaches can influence the decision choice of influencing factors. The methods used are given in Figure 2.

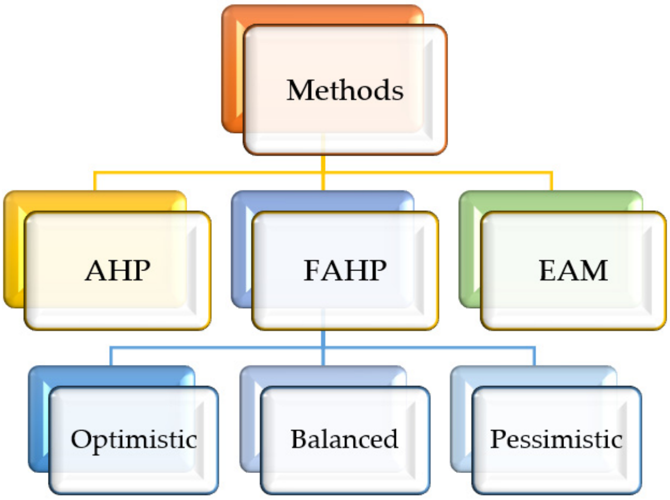

Figure 2. Schematic representation of methods.

3. Materials and Methods

AHP is a structured technique that enables the organization and analysis of complex decisions based on subjective assessment. Using multiple criteria for easy to understand and efficient dealing with qualitative and quantitative data are the main advantages of AHP.

Definition 1. *AHP is a multi-criteria decision-making technique to highlight the advantages among different criteria in the decision-making, compare decision-making alternatives for each criterion, and obtain the final ranking of decision alternatives. The outcome in AHP is deciding on the best of the decision alternatives.*

The AHP method is realized through the following steps [35]:

(1) Establishing a hierarchy by decomposing the problem of decision-making.
(2) Creating comparison matrices by performing pairwise comparisons.
(3) Calculation of weights and consistency of comparisons.
(4) Aggregation of weights to obtain results and ranking of alternatives.

AHP has been used in various domains like business, industry, and engineering. Developing countries should use AHP for complex economic problems solutions from different development perspectives [36]. The essence of the AHP method is to pair the available options according to all evaluation criteria [37]. In the real world, data or information obtained from experts mainly includes uncertainty and ambiguity conditioned primarily by inaccuracies in human reasoning and decision-making environment uncertainty and incomplete details [38].

As a more powerful methodology for multi-criteria decision-making, the combined effect of fuzzy set theory and AHP is given by the FAHP. The FAHP method is applicable for solving the problem of multi-criteria analysis when accurately assessing (quantifying) the impact of indicators on the decision problem is not present. In addition, the introduction of the AHP or FAHP method allows minimizing subjective influences in decision- making.

3.1. Triangular Fuzzy Numbers and Fuzzy AHP Method

The fuzzy numbers are special fuzzy sets $F = \{(x, \mu_F(x)), x \in \mathbb{R}\}$, where $\mu_F : R \to [0, 1]$ is a continuous function. The triangular fuzzy number (TFN), denoted with $\widetilde{T} = (a, m, b)$, has membership function:

$$\mu_{\widetilde{T}}(x) = \begin{cases} \dfrac{x-a}{m-a}, & x \in [a, m) \\ \dfrac{b-x}{b-m}, & x \in [m, b] \\ 0, & \text{otherwise.} \end{cases} \tag{1}$$

Definition 2. *For two triangular fuzzy numbers* $\widetilde{T}_1 = (a_1, m_1, b_1)$ *and* $\widetilde{T}_2 = (a_2, m_2, b_2)$, *and scalar* $\lambda \in R$ *arithmetic operations are:*

- *Addition:* $\widetilde{T}_1 \oplus \widetilde{T}_2 = (a_1 + a_2, m_1 + m_2, b_1 + b_2)$,
- *Subtraction:* $\widetilde{T}_1 \ominus \widetilde{T}_2 = (a_1 - b_2, m_1 - m_2, b_1 - a_2)$,
- *Multiplication:* $\widetilde{T}_1 \odot \widetilde{T}_2 = (a_1 \cdot a_2, m_1 \cdot m_2, b_1 \cdot b_2)$,
- *Inverse:* $T_1^{-1} = (a_1,\ m_1,\ b_1)^{-1} = (1/b_1, 1/m_1, 1/a_1)$,
- *Division:* $\widetilde{T}_1 \oslash \widetilde{T}_2 = \widetilde{T}_1 \odot T_2^{-1} = (a_1/b_2, m_1/m_2, b_1/a_2)$,
- *Scalar multiplication:* $\lambda\widetilde{T}_1 = (\lambda a_1, \lambda m_1, \lambda b_1)$.

Denotations and meaning of the triangular fuzzy numbers (TFNs) are: $\widetilde{1} = (1,\ 1,\ 3)$ is equal importance (both elements have the same impact); $\widetilde{3} = (1,\ 3,\ 5)$ is moderate importance (one element has a slight advantage over the other); $\widetilde{5} = (3,\ 5,\ 7)$ strong importance (strong advantage of one element over the other); $\widetilde{7} = (5,\ 7,\ 9)$ very strong or demonstrated importance (very strong advantage of one element over the other); $\widetilde{9} = (7,\ 9,\ 9)$ extreme importance (extreme (full) advantage of one element over the other). Intermediate values are $\widetilde{2} = (1,\ 2,\ 3)$, $\widetilde{4} = (3,\ 4,\ 5)$, $\widetilde{6} = (5,\ 6,\ 7)$ and $\widetilde{8} = (7,\ 8,\ 9)$.

In recent decades, the fuzzy AHP method, based primarily on triangular fuzzy numbers, has proven suitable in a wide range of engineering, environment, industry, economy, etc. Since fuzzy weights are not as easy to calculate as crisp weights, most Fuzzy AHP applications use the extent analysis method proposed by Chang [30]. Like AHP, FAHP facilitates decompositions and comparisons in pairs, provides a hierarchical structure, and generates priority vectors while reducing in-consistencies. Also, fuzzy AHP can be used to solve different problems and different contexts.

The applied method consists of the following:

(1) Establishing the main goal and the criteria and sub-criteria contributing to the overall goal; developing the problem hierarchy.

(2) Obtaining the fuzzy comparison matrices. A pairwise comparison has been made using a fuzzified evaluation scale. Using triangular fuzzy numbers, we form a comparison matrix $\widetilde{C} = (\widetilde{c}_{ij})_{n \times n}$ for a fuzzy comparison of criteria by pairs, where $\widetilde{c}_{ij}$ is a fuzzy value that expresses the relative importance of one criterion to another. At the diagonal, the fuzzy values $\widetilde{c}_{ii}$ express the relative importance of the criterion to itself. Because of that, we put that $\widetilde{c}_{ii} = (1, 1, 1)$. The aggregation of different experts' opinions is calculated by the averaging method. Based on the corresponding linguistic assessments of k experts (a_i, m_i, b_i), aggregated crisp value has been obtained by $1/k \sum_{i=1}^{k} m_i$ rounding to the nearest integer. The corresponding fuzzy number value of the aggregate opinion is then obtained.

(3) Examination of the comparison matrix $\widetilde{C}$ consistency. We calculate the consistency index CI and consistency ratio CR for matrix $\widetilde{C} = \left(\widetilde{c}_{ij}\right)_{n\times n}$ by $CI = \frac{\lambda_{max}-n}{n-1}$, $CR = \frac{CI}{RI}$, where λ_{max} represents the maximal eigenvalues, and RI is an accepted random index of a matrix $\widetilde{C}$. The value $CR \leq 0.10$ implies that we accept evaluated fuzzy elements of the matrix, while otherwise, we must remove the reasons for undesirably high estimations and repeat comparison in pairs until the degree of consistency belongs to desirable limits.

(4) The fuzzy synthetic extents determination. The synthetic triangular fuzzy numbers have been calculated, according to Chang's extent analysis method, by using triangular fuzzy numbers from the matrix $\widetilde{C} = \left(\widetilde{c}_{ij}\right)_{n\times n}$:

$$\widetilde{\mathcal{S}}_i = \sum_{j=1}^{n} \widetilde{c}_{ij} \odot \left(\sum_{i=1}^{n}\sum_{j=1}^{n} \widetilde{c}_{ij}\right)^{-1}, i = \overline{1,n}. \tag{2}$$

First approach, Extent analysis method (EAM) [30]: The obtained synthetic triangular fuzzy numbers can be compared one with each other by calculating the degree of possibility that $\widetilde{T}_1 \geq \widetilde{T}_2$:

$$P\left(\widetilde{T}_1 \geq \widetilde{T}_2\right) = \sup_{x\geq y}\left[\min\left(\mu_{\widetilde{T}_1}(x), \mu_{\widetilde{T}_2}(y)\right)\right]. \tag{3}$$

This probability P has been approximated by the ordinate of the intersection point with abscise d (see Figure 3).

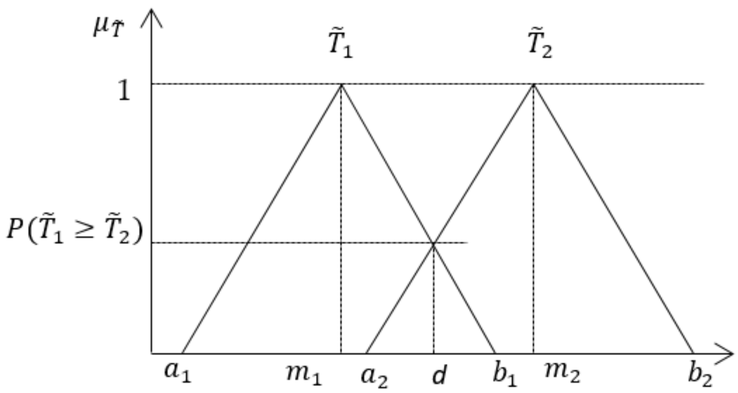

Figure 3. Intersection between membership functions $\mu_{\widetilde{T}_1}$ and $\mu_{\widetilde{T}_2}$.

By calculating ordinate of this intersection point, we obtain

$$P\left(\widetilde{T}_1 \geq \widetilde{T}_2\right) = \text{hgt}\left(\widetilde{T}_1 \cap \widetilde{T}_2\right) = \begin{cases} 1, & if\ m_1 \geq m_2 \\ 0, & if\ a_2 \geq b_1 \\ \dfrac{a_2-b_1}{(m_1-b_1)-(m_2-a_2)}, & otherwise. \end{cases} \tag{4}$$

The degree of possibility that convex fuzzy number $\widetilde{T}$ is greater than k convex fuzzy numbers $\widetilde{T}_i$, $i = \overline{1,k}$ is

$$P\left(\widetilde{T} \geq \widetilde{T}_1, \widetilde{T}_2, \ldots, \widetilde{T}_k\right) = \min P\left(\widetilde{T} \geq \widetilde{T}_i\right), \text{for } i = \overline{1,k}. \tag{5}$$

Let $d'(C_i) = \min P(\mathcal{S}_i \geq \mathcal{S}_k)$, for $k = \overline{1,n}$, $k \neq i$. The weight vector is $\mathcal{W}' = \left(d'(C_1), d'(C_2), \ldots, d'(C_n)\right)^T$, where C_i, $i = \overline{1,n}$ are n elements. The normalized weight vector is a non-fuzzy number:

$$\mathcal{W} = \left(d(C_1), d(C_2), \ldots, d(C_n)\right)^T, \tag{6}$$

which we can denote $\mathcal{W} = (\omega_1, \omega_2, \ldots, \omega_n)^T$.

Second approach: Based on total integral values calculated by [39],

$$\omega_i'\left(\widetilde{S}_i\right) = 0.5(\nu b_i + m_i + (1-\nu)a_i),\ i = \overline{1,n},\ \nu \in [0,1], \quad (7)$$

We compare obtained TFNs: $\widetilde{S}_i = (a_i,\ m_i, b_i)$. Real constant ν represents an optimism index, which explains the decision maker's attitude toward the risk. The smaller values mean a higher degree of risk and a lower degree of optimism. In our research we have used values: $\nu = 0$ (pessimistic viewpoints), $\nu = 0.5$ (balanced viewpoints), and $\nu = 1$ (optimistic viewpoints).

By normalization, we obtain the weight vector: $\mathcal{W} = (\omega_1, \omega_2, \ldots, \omega_n)^T$.

3.2. Considering Indicators for the Sustainable Economic Development

Factors influencing the implementation of the concept of natural and human resources management for the economic development of Serbia are expressed through four groups of criteria: a framework for strengthening participation in development, human resources, economic potential, natural resources, and are shown in Table 1.

Table 1. The overview of adopted indicators for the sustainable economic development.

S—Strengthening participation in the development [40]	
S_1—Economic development strategy based on knowledge and innovation [41,42]	S_{11}—Development of a stimulating entrepreneurial environment [43]
	S_{12}—Targeted investment attraction [44]
	S_{13}—Development of potentials for the needs of the labor market
S_2—Sustainable mobility and interactive city development [45,46]	S_{21}—Increased accessibility of the city
	S_{22}—Sustainable mobility of the central city zone [47]
	S_{23}—Development of economic zones and logistics
	S_{24}—Compliance of the traffic system with the needs of citizens
	S_{25}—Increasing the share of pedestrians in cyclists as road users [48]
	S_{26}—Improved safety conditions for all road users
S_3—Improvement and development infrastructure services of citizens [49]	S_{31}—Improving the quality of communal infrastructure
	S_{32}—Creating a framework for high-quality utilities
	S_{33}—Improving the level of information and communication with citizens
S_4—Energy capital as a development opportunity [50]	S_{34}—Increased efficiency coefficient of all PUCs individually
	S_{41}—Improvement of energy infrastructure
	S_{42}—Improving energy efficiency
	S_{43}—Institutional environment for the development of energy systems and the provision of quality services [51]
S_5—Improved social cohesion [52]	S_{44}—Achieved in the billing system according to the energy consumed
	S_{51}—Diversified, accessible, and quality social services
	S_{52}—Improving the content of culture, sports, and tourism
	S_{53}—Improving social development infrastructure
	S_{54}—A single record system for users of social rights and services has been established
	S_{55}- City Housing Strategy adopted
	S_{56}—Implementation of investment plans in facilities and equipment of primary health care institutions
E—Economic potentials [53]	
E_1—Increasing competitiveness [54,55]	E_{11}—Stability of business environment and business sector [56]
	E_{12}—Global response to the COVID-19 pandemic [57]
E_2—Suppression of the gray economy [58]	E_{21}—Reducing the degree of the gray economy in GDP [59]
	E_{22}—Reduction of the share of unregistered economic entities
	E_{23}—Relative reduction of VAT
E_3—Public-private partnership in support of local economic development and foreign direct investment (FDI) [60]	E_{31}- Increase in efficiency and economy [61]
	E_{32}- Reducing the pressure of public investment on the budget [62]
	E_{33}- Increasing the level of foreign direct investment (FDI)

Table 1. *Cont.*

	N—Natural resources [63]
N_1—Use and protection of natural resources in planning [64]	N_{11}—Implementation of the National Strategy on the Use and Protection of Natural Resources and Goods
	N_{12}—Strategic environmental impact assessment of plans and programs
	N_{13}—Environmental impact assessment of projects
	N_{14}—Integrated prevention and control of environmental pollution
N_2—Management of renewable natural resources and non-renewable natural resources [65]	N_{21}—Reconciliation of the relationship between the degree of exhaustion of natural resources and their regeneration rate [66]
	N_{22}—Design of available resources by quality, structure, amount, and capital investments
	N_{23}—Direction of ecological aspects in the interest of the population of the local area
N_3—Protection of resources and ecosystems through the principles of sustainable development [67]	N_{31}—Creating ability of the environment to accept a certain amount of pollutants per unit of time and space so that there is no irreversible damage to the environment;
	N_{32}—The impact of a product/service or system on the environment
	N_{33}—Effective preservation of ecosystems and resources themselves [68]
	N_{34}—Transparency-information of the wider local community
	H—Human resources [69]
H_1—Employment and labor market [70]	H_{11}—Support for the development of local and inter-municipal employment policies
	H_{12}—Increasing the impact of employment policy measures on the hard-to-employ
	H_{13}—Suppression of the informal economy
H_2—Improving the quality and accessibility of health services [71]	H_{21}—Promoting the health and well-being of all citizens
	H_{22}—Preventive care
	H_{23}—Strengthening the operational capacity of the health system in line with EU standards data
H_3—Education [72]	H_{31}—Improving the quality and importance of secondary vocational education and adult education within the National Qualifications Framework
	H_{32}—Ensuring access to and reaching higher levels of education for children at risk [73]
	H_{33}—Education for all
H_4—Social inclusion [74]	H_{41}—Support for social inclusion through a more diverse offer of social services in the local community
	H_{42}—Support for the transition from social assistance to work ("welfare-to-work") through activation
H_5—Technical assistance	H_{51}—Announcement of new calls for cross-border cooperation programs
	H_{52}—Finalization of the Operational Program Human Resources Development
	H_{53}—Negotiations with individual bilateral donors, discussions on a new EU financial perspective [75]

4. Results and Discussion

In this section, the outlined algorithms have been applied. A group of experts in the area of economy, natural resources, and human resources rated the identification of decision criteria. Expert opinions are expressed based on the meaning and denotation of TFNs in Table 2. Expert assessments are aggregated based on the algorithm explanation in step (2). Experts agreed that some groups should retain a number of sub-criteria.

Table 3 shows a matrix comparing the primary criteria, and Figure 4 shows the corresponding weights.

Tables A1–A20 with triangular fuzzy comparison matrices of sub-criteria and the corresponding weights for applied methods are in Appendix A.

The final rank of sub-sub-criteria, and their final weight for each sub-criterion, are in Table 4. The indicators are ranked according to the optimistic, balanced, and pessimistic views ($\nu = 1$, $\nu = 0.5$, $\nu = 0$), the extent analysis method (EAM) on FAHP and AHP.

Table 2. Meaning and denotation of the TFNs.

Description TFNs	TFNs	Inverse TFNs	Denotation of TFNs	Denotation of Inverse TFNs
Equally important	$\tilde{1} = (1, 1, 3)$	$\tilde{1} - 1 = (1/3, 1, 1)$	E	1/E
Equally to weakly important	$\tilde{2} = (1, 2, 3)$	$\tilde{2} - 1 = (1/3, 1/2, 1)$	EW	1/EW
Weakly important	$\tilde{3} = (1, 3, 5)$	$\tilde{3} - 1 = (1/5, 1/3, 1)$	W	1/W
Weakly to strong important	$\tilde{4} = (3, 4, 5)$	$\tilde{4} - 1 = (1/5, 1/4, 1/3)$	WS	1/WS
Strong important	$\tilde{5} = (3, 5, 7)$	$\tilde{5} - 1 = (1/7, 1/5, 1/3)$	S	1/S
Strong to very strongly important	$\tilde{6} = (5, 6, 7)$	$\tilde{6} - 1 = (1/7, 1/6, 1/5)$	SV	1/SV
Very strongly important	$\tilde{7} = (5, 7, 9)$	$\tilde{7} - 1 = (1/9, 1/7, 1/5)$	V	1/V
Very strongly to absolutely important	$\tilde{8} = (7, 8, 9)$	$\tilde{8} - 1 = (1/9, 1/8, 1/7)$	VA	1/VA
Absolutely important	$\tilde{9} = (7, 9, 9)$	$\tilde{9} - 1 = (1/9, 1/9, 1/7)$	A	1/A

Table 3. Triangular fuzzy compare matrix of primary criteria.

	F	S	N	H
F	$\tilde{1}$	$\tilde{1}$	$\tilde{2}$	$\tilde{4}$
S	$\tilde{1} - 1$	$\tilde{1}$	$\tilde{2}$	$\tilde{4}$
N	$\tilde{2} - 1$	$\tilde{2} - 1$	$\tilde{1}$	$\tilde{3}$
H	$\tilde{4} - 1$	$\tilde{4} - 1$	$\tilde{3} - 1$	$\tilde{1}$

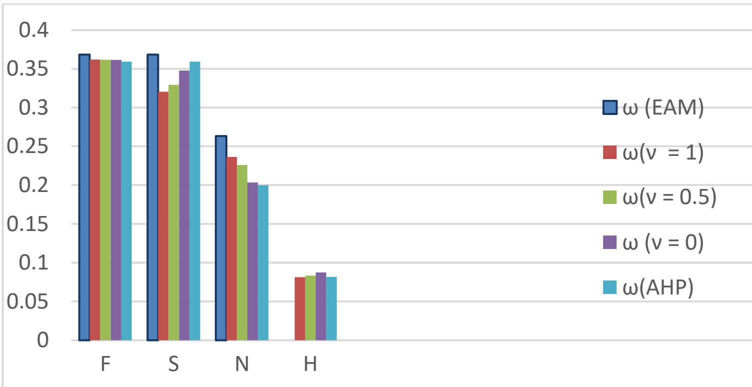

Figure 4. Corresponding weights for Chang's approach, different degrees of optimism in FAHP and crisp AHP ($CI = 0.006$, $CR = 0.007$).

The final sequence of influencing factors (with weights) in managing natural and human resources for economic and regional development can be seen in Figure 5.

The results obtained by applying classical AHP and FAHP methods, whether they are different degrees of optimism or Chang's approach, are favored as the most influential factor stability of the environment and business sector.

Based on the obtained final weights that represent the optimistic attitudes of decision-makers, the following are significant reductions in the pressure of public investment on the budget, efficient conservation of ecosystems and resources, and the global response to the COVID-19 pandemic. In the pessimistic scenario, the following indicators stand out: the development of a stimulating entrepreneurial environment, reducing the pressure of public investment on the budget, and global response to the COVID-19 pandemic. In the balanced scenario, the development of a stimulating entrepreneurial environment, reducing the pressure of public investments on the budget, efficient preservation of ecosystems and resources, as well as the global response to the COVID-19 pandemic are still important indicators.

Differences can be seen in the second factor of influence Chang's approach and optimistic attitude favor reducing the pressure of public investment on the budget, and moderate and pessimistic attitudes, as well as the AHP method, emphasize the development of a stimulating entrepreneurial environment.

In both scenarios, the same group of indicators stands out by the dominant factor being the stability of the business environment and the business sector. However, the development of a stimulating entrepreneurial environment is not among the significant factors in the optimistic scenario, unlike the pessimistic one. On the other hand, efficient conservation of ecosystems and resources themselves resource-related environmental factors are not so significant in this scenario.

Table 4. Ranking of indicators with final weights by triangular fuzzy AHP method, AHP method and IAHP method ($I\omega$ is interval weight, p is probability).

	ω_{EAM}		$\omega_{v=1}$		$\omega_{v=0.5}$		$\omega_{v=0}$		$I\omega$	p		$\omega(AHP)$
E_{11}	0.100666	E_{11}	0.095156	E_{11}	0.094012	E_{11}	0.091420	S_{11}	[8.63826,19.0926]	0.959395	E_{11}	0.095807
E_{32}	0.068298	E_{32}	0.060143	S_{11}	0.077816	S_{11}	0.077491	S_{12}	[4.75382,10.9277]	0.66159	S_{11}	0.088968
S_{11}	0.064537	N_{33}	0.056326	E_{32}	0.062224	E_{32}	0.066205	E_{21}	[4.70912,8.97667]	0.871921	E_{32}	0.077548
N_{33}	0.062361	E_{12}	0.047578	N_{33}	0.053412	E_{12}	0.050789	N_{33}	[3.92281,6.33196]	0.520358	N_{33}	0.053058
E_{31}	0.048790	S_{12}	0.043947	E_{12}	0.048828	S_{12}	0.048970	S_{26}	[3.17891,6.9234]	0.816068	S_{12}	0.048961
N_{31}	0.048423	N_{31}	0.041460	S_{12}	0.045329	N_{33}	0.047105	S_{22}	[2.92868,4.77265]	0.558448	E_{12}	0.047903
S_{12}	0.046103	N_{21}	0.037358	N_{31}	0.038585	E_{31}	0.041838	S_{13}	[2.07642,5.25352]	0.513292	E_{31}	0.042676
E_{12}	0.044741	E_{31}	0.033894	E_{31}	0.036246	E_{21}	0.033955	S_{34}	[2.80168,4.4438]	0.5	E_{21}	0.035341
N_{21}	0.041493	S_{11}	0.032996	N_{21}	0.035811	N_{31}	0.032727	S_{33}	[2.80168,4.4438]	0.747129	N_{31}	0.032964
E_{21}	0.039108	E_{21}	0.028827	E_{21}	0.030422	N_{21}	0.032503	E_{11}	[2.64639,3.76592]	0.550364	N_{21}	0.032035
S_{33}	0.030624	S_{13}	0.025371	S_{13}	0.025999	S_{13}	0.027660	S_{43}	[1.81144,4.34561]	0.5	S_{13}	0.026944
S_{34}	0.030624	S_{33}	0.025188	S_{33}	0.025013	S_{33}	0.024555	S_{42}	[1.81144,4.34561]	0.520348	S_{33}	0.023801
E_{22}	0.030367	S_{34}	0.022304	S_{34}	0.022765	E_{33}	0.023632	E_{32}	[2.69886,3.35506]	0.730681	S_{34}	0.023801
N_{22}	0.029641	E_{22}	0.021219	E_{22}	0.021977	S_{34}	0.023616	H_{31}	[1.88112,3.4493]	0.512562	E_{33}	0.023486
E_{33}	0.028319	N_{22}	0.021053	N_{22}	0.020861	E_{22}	0.023591	N_{31}	[2.17212,3.1189]	0.774858	E_{22}	0.021957
S_{13}	0.026760	S_{22}	0.020602	E_{33}	0.020789	N_{22}	0.020540	S_{52}	[1.64082,2.90676]	0.552408	H_{31}	0.021409
S_{31}	0.021887	E_{33}	0.019567	S_{22}	0.020150	H_{31}	0.020205	S_{25}	[1.73775,2.67714]	0.5	S_{22}	0.018137
S_{22}	0.021309	S_{26}	0.019114	S_{26}	0.018968	S_{22}	0.018909	S_{21}	[1.73775,2.67714]	0.662139	S_{26}	0.018137
S_{26}	0.021309	N_{32}	0.018122	H_{31}	0.018368	S_{26}	0.018462	S_{31}	[1.55898,2.51796]	0.739001	N_{22}	0.017630
N_{11}	0.018888	H_{31}	0.017541	N_{32}	0.016783	S_{42}	0.014893	E_{22}	[1.46285,2.14209]	0.646789	H_{11}	0.013773
N_{12}	0.018888	S_{31}	0.016464	S_{31}	0.015616	S_{43}	0.014236	E_{31}	[1.48524,1.92029]	0.675224	N_{32}	0.013462
N_{23}	0.017205	S_{42}	0.014756	S_{42}	0.014808	N_{32}	0.014087	E_{12}	[1.3232,1.88296]	0.73459	S_{42}	0.013400
S_{21}	0.016776	N_{11}	0.014742	N_{11}	0.014240	S_{31}	0.013822	H_{11}	[1.21722,1.7032]	0.513748	S_{43}	0.013400
S_{25}	0.016015	S_{21}	0.013937	H_{11}	0.013434	H_{11}	0.013601	S_{51}	[1.04206,1.85598]	0.588416	S31	0.013244
N_{13}	0.013499	H_{11}	0.013332	S_{43}	0.013270	H_{41}	0.013558	S_{41}	[0.9555,1.78963]	0.577056	N_{11}	0.011738
S_{42}	0.013147	N_{12}	0.013053	S_{21}	0.013236	N_{11}	0.013197	S_{24}	[1.03337,1.58321]	0.618407	N_{12}	0.011738
S_{43}	0.013147	S_{43}	0.012920	N_{12}	0.012960	N_{12}	0.012693	N_{22}	[1.1401,1.34627]	0.5	H_{41}	0.011126
N_{32}	0.012876	H_{41}	0.012639	H_{41}	0.012918	N_{23}	0.011602	N_{21}	[1.1401,1.34627]	0.718915	S_{21}	0.010174
S_{24}	0.010677	S_{25}	0.012449	S_{25}	0.012054	S_{21}	0.011464	H_{33}	[0.71778,1.44861]	0.602178	S_{25}	0.010174
S_{41}	0.009492	N_{23}	0.012154	N_{23}	0.011965	S_{25}	0.011017	N_{11}	[0.759,1.25804]	0.540678	N_{23}	0.009702
E_{23}	0.008075	N_{13}	0.009635	E_{23}	0.009559	E_{23}	0.010155	N_{34}	[0.83114,1.1453]	0.5	E_{23}	0.008967
S_{44}	0.006231	N_{34}	0.009309	N_{34}	0.009049	S_{41}	0.008886	N_{32}	[0.83114,1.1453]	0.661054	S_{52}	0.008699
S_{52}	0.004730	E_{23}	0.009275	N_{13}	0.008890	H_{33}	0.008564	H_{41}	[0.70149,1.13498]	0.603941	N_{34}	0.008393
S_{23}	0.004462	S_{52}	0.008171	S_{52}	0.008215	N_{34}	0.008375	S_{54}	[0.61831,1.11409]	0.5	H_{33}	0.008169
S_{51}	0.003829	S_{24}	0.008006	H_{33}	0.008014	S_{52}	0.008284	S_{53}	[0.61831,1.11409]	0.661846	S_{41}	0.007220
S_{53}	0.002731	H_{33}	0.007756	S_{41}	0.007970	N_{13}	0.007429	E_{33}	[0.64874,0.92318]	0.56956	N_{13}	0.006531
S_{54}	0.002429	S_{41}	0.007645	S_{24}	0.007702	S_{24}	0.006919	N_{12}	[0.672,0.86174]	0.550236	S_{24}	0.005896
S_{55}	0.001546	H_{12}	0.006962	H_{12}	0.006820	H_{12}	0.006396	S_{23}	[0.5046,0.98125]	0.501867	E_{24}	0.005590
S_{32}	0.000000	S_{51}	0.006134	S_{51}	0.005987	E_{24}	0.006037	S_{32}	[0.52952,0.95455]	0.58258	H_{12}	0.005585
S_{56}	0.000000	S_{32}	0.005652	S_{32}	0.005756	S_{32}	0.005944	S_{44}	[0.33614,1.03286]	0.513851	S_{51}	0.005525
E_{24}	0.000000	H_{23}	0.005442	H_{23}	0.005474	S_{51}	0.005637	E_{23}	[0.49956,0.85014]	0.700636	S_{32}	0.005401
N_{14}	0.000000	S_{44}	0.004830	E_{24}	0.005154	H_{23}	0.005448	H_{12}	[0.49356,0.7153]	0.716183	H_{32}	0.004676
N_{34}	0.000000	E_{24}	0.004764	S_{44}	0.004904	S_{44}	0.005098	S_{55}	[0.37522,0.69381]	0.663563	H_{23}	0.004669
H_{11}	0.000000	S_{23}	0.004646	S_{23}	0.004527	H_{32}	0.004968	H_{32}	[0.28485,0.65808]	0.544825	S_{44}	0.004167
H_{12}	0.000000	S_{53}	0.004210	S_{53}	0.004165	S_{23}	0.004209	H_{23}	[0.40115,0.50832]	0.595829	S_{23}	0.003729
H_{13}	0.000000	H_{21}	0.003982	H_{32}	0.004122	S_{53}	0.004051	N_{13}	[0.40942,0.47951]	0.586548	S_{53}	0.003278
H_{21}	0.000000	S_{54}	0.003780	S_{54}	0.003825	S_{54}	0.003912	E_{24}	[0.32312,0.53]	0.558802	S_{54}	0.003278
H_{22}	0.000000	H_{32}	0.003759	H_{21}	0.003729	N_{14}	0.003195	N_{23}	[0.38003,0.44876]	0.840303	H_{51}	0.002742
H_{23}	0.000000	N_{14}	0.003308	N_{14}	0.003277	H_{21}	0.003178	H_{51}	[0.23827,0.44786]	0.89211	H_{21}	0.002673
H_{31}	0.000000	S_{55}	0.002765	S_{55}	0.002636	H_{42}	0.003106	H_{21}	[0.2296,0.29094]	0.898511	N_{14}	0.002664
H_{32}	0.000000	H_{51}	0.002492	H_{51}	0.002593	H_{51}	0.002828	H_{13}	[0.17111,0.26352]	0.500174	H_{13}	0.002265
H_{33}	0.000000	H_{13}	0.002358	H_{42}	0.002530	H_{13}	0.002678	S_{56}	[0.13099,0.30358]	0.794194	H_{42}	0.002020
H_{41}	0.000000	H_{42}	0.002253	H_{13}	0.002452	S_{55}	0.002339	N_{14}	[0.13746,0.19556]	0.778545	S_{55}	0.001989
H_{42}	0.000000	H_{22}	0.001349	H_{22}	0.001351	H_{22}	0.001331	H_{42}	[0.11091,0.17946]	0.999997	H_{22}	0.001020
H_{51}	0.000000	H_{52}	0.001067	H_{52}	0.001130	H_{52}	0.001269	H_{22}	[0.08761,0.11101]	0.615939	S_{56}	0.000952
H_{52}	0.000000	S_{56}	0.000987	S_{56}	0.001011	S_{56}	0.001063	H_{52}	[0.06855,0.11849]	1	H_{52}	0.000903
H_{53}	0.000000	H_{53}	0.000268	H_{53}	0.000298	H_{53}	0.000360	H_{53}	[0.02376,0.03902]		H_{53}	0.00029

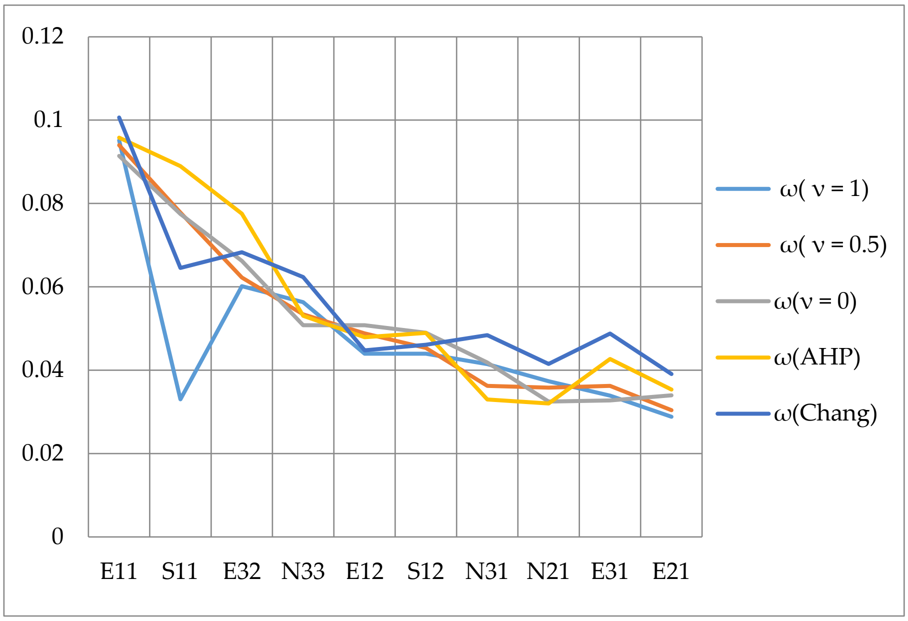

Figure 5. Graphical representation of final weights of influential indicators by AHP and FAHP with Chang approach and different degrees of optimism.

Although sustainable development has three dimensions: economic, environmental, and social, we have included in this study another dimension of the framework for strengthening participation in development to establish the extent to which indicators that stand out within this group affect economic growth and regional development. The optimistic scenario includes only one of these factors as the dominant ones, the targeted attraction of investments. The results obtained using the IAHP method favor precisely the indicators from this dimension because the estimates given using the interval method defined wider intervals that favored this group of factors. Thus, the most significant indicators by IAHP are the development of a stimulating entrepreneurial environment, targeted investment attraction, reducing the degree of the gray economy in GDP, effective preservation of ecosystems and resources themselves.

The measure chosen for the realization of comparative analysis of criterion weighting methods presented in this research is one of the most frequently used rank correlation coefficients used today to solve the problem of MCDM. Spearman's correlation coefficient represents the measure of the strength and direction of the correlation between two ranked criteria [76]. This coefficient is given by (8)

$$S_c = -\frac{6\sum_{i=1}^{n}\left(r_{x_i} - r_{y_i}\right)^2}{n\left(n^2-1\right)}, \tag{8}$$

where r_{x_i} and r_{y_i} are ranks of the element i in the compared rankings, n is the number of elements in the ranking.

WS method rank correlation coefficient is new, and was introduced in [77]. The main goal of this coefficient is to choose indicators that are closer to the top of the considered ranking. It provides a typical ranking scenario where the first three places are the most significant and targets differences in the given ranks depending on what changes in positions are observed. This coefficient is used in many decision-making problems and coefficient is calculated as shown in (9)

$$WS = 1 - \sum_{i=1}^{n}\left(2^{-r_{x_i}}\frac{\left|r_{x_i} - r_{y_i}\right|}{\max\{|1-r_{x_i}|, |n-r_{x_i}|\}}\right). \tag{9}$$

A comparative analysis of the similarity of the methods is given in Table 5.

Table 5. Comparison similarity analysis of methods.

	FAHP ν**=1**	**FAHP** ν**=0.5**	**FAHP** ν**=0**	**FAHP Chang**	**AHP**	**IAHP**
FAHP $\nu = 1$		$Sc = 0.997$ $WS = 0.964$	$Sc = 0.988$ $WS = 0.964$	$Sc = 0.877$ $WS = 0.991$	$Sc = 0.989$ $WS = 0.964$	$Sc = 0.836$ $Ws = 0.837$
FAHP $\nu = 0.5$			$Sc = 0.995$ $WS = 0.997$	$Sc = 0.871$ $WS = 0.991$	$Sc = 0.995$ $WS = 0.999$	$Sc = 0.845$ $WS = 0.877$
FAHP $\nu = 0$				$Sc = 0.852$ $WS = 0.986$	$Sc = 0.996$ $WS = 0.997$	$Sc = 0.838$ $WS = 0.865$
FAHP Chang					$Sc = 0.847$ $WS = 0.991$	$Sc = 0.836$ $WS = 0.837$
AHP						$Sc = 0.850$ $WS = 0.882$

Figure 5 highlights the most influential indicators for AHP, fuzzy AHP with Chang's (EAM) approach and the three-level optimism approach and Figure 6 shows the most influential factors singled out as measures by AHP and FAHP.

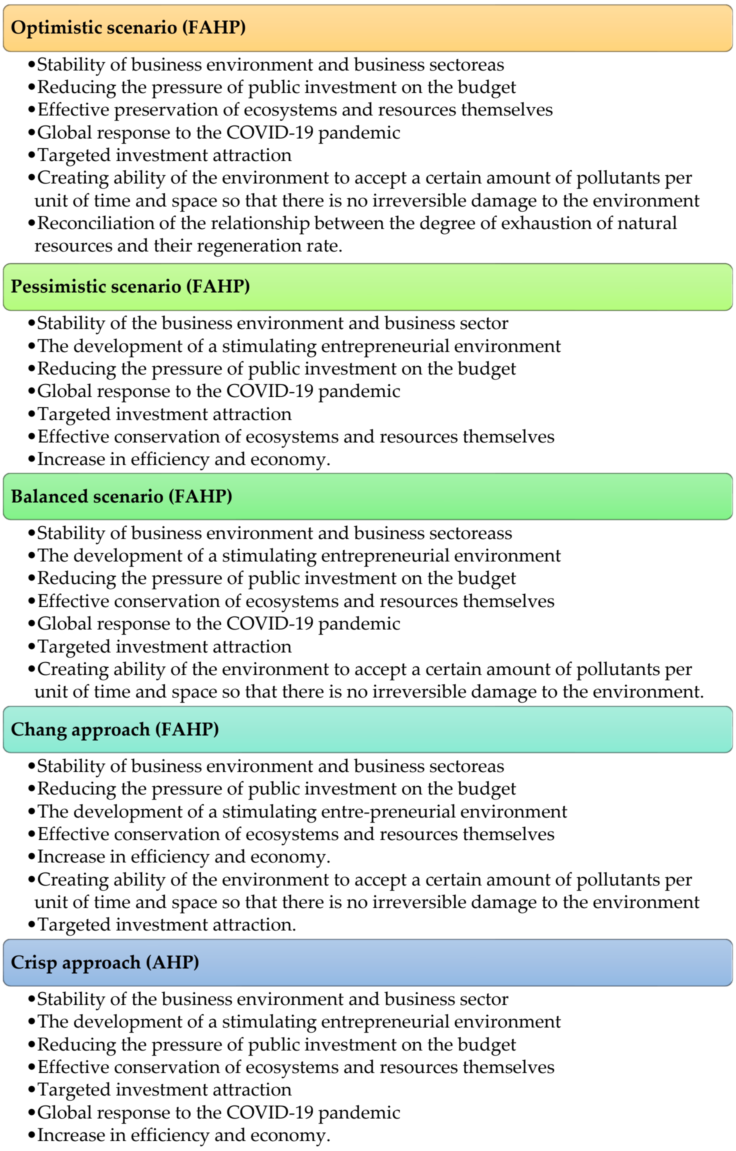

Figure 6. The most influential factors singled out as measures by AHP and FAHP.

5. Conclusions

Managing natural and human resources for economic and regional development is a global challenge that requires attention and importance in every society guided by the principles of sustainable development. Natural resources underpin economic activities in many ways. Issues about socially, environmentally, and economically sustainable promotion of growth in the best way have been increasingly at the heart of the interest. The strategy of economic development of the region includes defining a model for achieving the planned evolution of the state. Developing countries can apply a multi-criteria analysis in assessing and solving complex solvency problems from different perspectives. This paper examines the influential factors of sustainable economic development, taking into account the naturally available wealth also human resources as the backbone of the development of the region's economy. The paper discusses indicators divided into four groups a framework for strengthening participation in development, human social resources, economic potential, and natural resources. In recent decades, the FAHP method, based primarily on triangular fuzzy numbers, was proven suitable in a wide range of fields of engineering, environment, industry, economy, etc. The approach in the indicators' evaluation, given by unclear numbers, was significantly influenced the final results from the determination of influencing factors. Using methods, AHP and triangular fuzzy AHP, 57 different subcriteria are ranked for identifying priorities in resource management and economic regional development. The triangular fuzzy of the AHP indicates the importance of the stability of the environment and the business sector for different degrees of optimism, namely the Chang approach and the classic AHP. The IAHP approach indicates the importance of stimulating entrepreneurial environment development. The analysis of the similarity of the results gives a generally satisfactory degree of similarity, although the second indicator already differs in some scenarios. The proposed model offers five scenarios, and it is up to the managers to decide on the most acceptable option. Such a proposal provides enough flexibility for the decision-maker. In future research, we intend to apply the spherical fuzzy analytic hierarchy process to find the best model to support IoT influence factors of entrepreneurship.

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Appendix A

Table A1. Triangular fuzzy comparison j matrix of the criteria S and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.014,\ CR = 0.012$).

	S_1	S_2	S_3	S_4	S_5	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
S_1	E	W	W	WS	S	0.372998	0.407067	0.412316	0.426412	0.458904
S_2	1/W	E	E	EW	W	0.24581	0.217634	0.211868	0.196386	0.184391
S_3	1/W	1/E	E	EW	W	0.225686	0.192363	0.191169	0.187963	0.184391
S_4	1/WS	1/EW	1/EW	E	EW	0.114065	0.110957	0.113216	0.119281	0.106287
S_5	1/S	1/W	1/W	1/EW	E	0.041441	0.071978	0.071430	0.069958	0.0660273

Table A2. Triangular fuzzy comparison matrix of the sub-criteria S_1 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.004,\ CR = 0.007$).

	S_{11}	S_{12}	S_{13}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
S_{11}	E	EW	W	0.469703	0.529412	0.521753	0.502793	0.539615
S_{12}	1/E	E	EW	0.335539	0.298349	0.303927	0.317737	0.296961
S_{13}	1/W	1/EW	E	0.194758	0.172240	0.174320	0.179469	0.163424

Table A3. Triangular fuzzy comparison matrix of the sub-criteria S_2 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.008,\ CR = 0.006$).

	S_{21}	S_{22}	S_{23}	S_{24}	S_{25}	S_{26}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
S_{21}	E	1/EW	W	EW	E	1/EW	0.185275	0.176969	0.172707	0.161515	0.153574
S_{22}	EW	E	WS	W	EW	E	0.235335	0.261599	0.262923	0.266398	0.273782
S_{23}	1/W	1/WS	E	1/EW	1/W	1/WS	0.049273	0.058989	0.059074	0.059296	0.056289
S_{24}	1/EW	1/W	EW	E	1/EW	1/W	0.117913	0.101658	0.100503	0.097470	0.088998
S_{25}	1/E	1/EW	1/W	1/EW	E	1/EW	0.176870	0.158077	0.157289	0.155218	0.153574
S_{26}	1/EW	1/E	WS	1/EW	W	E	0.235335	0.242707	0.247505	0.260101	0.273782

Table A4. Triangular fuzzy comparison matrix of the sub-criteria S_3 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.006,\ CR = 0.007$).

	S_{31}	S_{32}	S_{33}	S_{34}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
S_{31}	E	W	1/EW	1/EW	0.263272	0.236521	0.225833	0.203452	0.199916
S_{32}	1/W	E	1/WS	1/WS	0	0.081199	0.083232	0.087490	0.081531
S_{33}	EW	WS	E	E	0.368364	0.361858	0.361721	0.361435	0.359276
S_{34}	EW	WS	1/E	E	0.368364	0.320422	0.329213	0.347623	0.359276

Table A5. Triangular fuzzy comparison matrix of sub-criteria S_4 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.003,\ CR = 0.003$).

	S_{41}	S_{42}	S_{43}	S_{44}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
S_{41}	E	1/EW	1/EW	EW	0.225915	0.190410	0.194622	0.206108	0.18906
S_{42}	EW	E	E	W	0.312898	0.367517	0.361595	0.345444	0.350913
S_{43}	EW	1/E	E	W	0.312898	0.321785	0.324043	0.330201	0.350913
S_{44}	1/EW	1/W	1/W	E	0.148289	0.120288	0.119741	0.118247	0.109114

Table A6. Triangular fuzzy comparison matrix of the sub-criteria S_5 and its weighs for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.020,\ CR = 0.016$).

	S_{51}	S_{52}	S_{53}	S_{54}	S_{55}	S_{56}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
S_{51}	E	1/EW	EW	EW	W	S	0.250825	0.235493	0.231698	0.222953	0.232901
S_{52}	EW	E	W	W	WS	SV	0.309864	0.313714	0.317928	0.327637	0.366723
S_{53}	1/EW	1/W	E	E	EW	WS	0.178903	0.161625	0.161192	0.160196	0.138193
S_{54}	1/EW	1/W	1/E	E	1/EW	WS	0.159103	0.145126	0.148022	0.154696	0.138193
S_{55}	1/W	1/WS	1/EW	1/EW	E	W	0.101304	0.106154	0.102018	0.092487	0.0838608
S_{56}	1/S	1/SV	1/WS	1/WS	1/W	E	0	0.037887	0.039141	0.042030	0.0401283

Table A7. Triangular fuzzy comparison matrix of the criteria E and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0,\ CR = 0$).

	E_1	E_2	E_3	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
E_1	E	EW	E	0.394737	0.445455	0.433884	0.409091	0.4
E_2	1/EW	E	1/EW	0.210526	0.200000	0.203857	0.212121	0.2
E_3	1/E	EW	E	0.394737	0.354545	0.362259	0.378788	0.4

Table A8. Triangular fuzzy comparison matrix of the sub-criteria E_1 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0,\ CR = 0$).

	E_{11}	E_{12}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
E_{11}	E	EW	0.692308	0.666667	0.658163	0.642857	0.666667
E_{12}	1/EW	1/E	0.307692	0.333333	0.341837	0.357143	0.333333

Table A9. Triangular fuzzy comparison matrix of the sub-criteria E_2 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.0161203$, $CR = 0.0179114$).

	E_{21}	E_{22}	E_{23}	E_{24}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
E_{21}	E	EW	WS	S	0.504296	0.449824	0.453298	0.460482	0.491839
E_{22}	1/EW	E	W	WS	0.391579	0.331107	0.327465	0.319933	0.305571
E_{23}	1/WS	1/W	E	EW	0.104125	0.144724	0.142439	0.137713	0.124793
E_{24}	1/S	1/WS	1/EW	E	0	0.074344	0.076798	0.081871	0.0777981

Table A10. Triangular fuzzy comparison matrix of the sub-criteria E_3 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.004,\ CR = 0.007$).

	E_{31}	E_{32}	E_{33}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
E_{31}	E	1/EW	EW	0.335539	0.298349	0.298349	0.317737	0.296961
E_{32}	EW	E	W	0.469703	0.529412	0.529412	0.502793	0.539615
E_{33}	1/EW	1/W	E	0.194758	0.172240	0.172240	0.179469	0.163424

Table A11. Triangular fuzzy comparison matrix of the criteria N and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.004,\ CR = 0.007$).

	N_1	N_2	N_3	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
N_1	E	1/EW	1/W	0.194758	0.17224	0.17432	0.179469	0.163424
N_2	EW	E	1/EW	0.335539	0.298349	0.303927	0.317737	0.296961
N_3	W	EW	E	0.469703	0.529412	0.521753	0.502793	0.539615

Table A12. Triangular fuzzy comparison matrix of the sub-criteria N_1 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.006,\ CR = 0.007$).

	N_{11}	N_{12}	N_{13}	N_{14}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
N_{11}	E	EW	EW	WS	0.368364	0.361858	0.361721	0.361435	0.359276
N_{12}	E	EW	EW	WS	0.368364	0.320422	0.329213	0.347623	0.359276
N_{13}	1/EW	1/EW	E	W	0.263272	0.236521	0.225833	0.203452	0.199916
N_{14}	1/WS	1/WS	1/W	E	0	0.081199	0.083232	0.087490	0.081531

Table A13. Triangular fuzzy comparison matrix of the sub-criteria N_2 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.004,\ CR = 0.007$).

	N_{21}	N_{22}	N_{23}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
N_{21}	E	EW	W	0.469703	0.529412	0.521753	0.502793	0.539615
N_{22}	1/EW	E	EW	0.335539	0.298349	0.303927	0.317737	0.296961
N_{23}	1/W	1/EW	E	0.194758	0.17224	0.17432	0.179469	0.163424

Table A14. Triangular fuzzy comparison matrix of the sub-criteria N_3 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.016,\ CR = 0.017$).

	N_{31}	N_{32}	N_{33}	N_{34}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
N_{31}	E	W	1/EW	WS	0.391579	0.331107	0.327465	0.319933	0.305571
N_{32}	1/W	E	1/WS	EW	0.104125	0.144724	0.142439	0.137713	0.124793
N_{33}	EW	WS	E	S	0.504296	0.449824	0.453298	0.460482	0.491839
N_{34}	1/WS	1/EW	1/S	E	0	0.074344	0.076798	0.081871	0.0777981

Table A15. Triangular fuzzy comparison matrix of the criteria H and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.024,\ CR = 0.022$).

	H_1	H_2	H_3	H_4	H_5	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
H_1	E	W	1/EW	EW	S	0.302687	0.278976	0.2728	0.259174	0.265205
H_2	1/W	E	1/WS	1/EW	W	0.121185	0.132675	0.12679	0.113806	0.10256
H_3	EW	WS	E	W	SV	0.375703	0.357825	0.366489	0.385604	0.420131
H_4	1/EW	EW	1/W	E	WS	0.200425	0.183401	0.185608	0.190476	0.163751
H_5	1/S	1/W	1/SV	1/WS	E	0	0.047122	0.0483131	0.05094	0.048352

Table A16. Triangular fuzzy comparison matrix of the sub-criteria H_1 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.019,\ CR = 0.033$).

	H_{11}	H_{12}	H_{13}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
H_{11}	E	W	S	0.573349	0.588534	0.591657	0.599821	0.636986
H_{12}	1/W	E	W	0.375448	0.307359	0.300366	0.282085	0.258285
H_{13}	1/S	1/W	E	0.0512038	0.104107	0.107977	0.118094	0.104729

Table A17. Triangular fuzzy comparison matrix of the H_2 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.009,\ CR = 0.015$).

	H_{21}	H_{22}	H_{23}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
H_{21}	E	W	1/EW	0.423486	0.369599	0.35333	0.319177	0.319618
H_{22}	1/W	E	1/WS	0	0.125255	0.127978	0.133695	0.121957
H_{23}	EW	WS	E	0.576514	0.505146	0.518692	0.547127	0.558425

Table A18. Triangular fuzzy comparison matrix of the sub-criteria H_3 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.009,\ CR = 0.015$).

	H_{31}	H_{32}	H_{33}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
H_{31}	E	WS	W	0.686499	0.603699	0.60215	0.598899	0.625013
H_{32}	1/WS	E	1/EW	0	0.129365	0.135136	0.147250	0.1365
H_{33}	1/W	EW	E	0.313501	0.266935	0.262714	0.253851	0.238487

Table A19. Triangular fuzzy comparison matrix of the sub-criteria H_4 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0,\ CR = 0$).

	H_{41}	H_{42}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
H_{41}	E	S	1	0.848684	0.836219	0.813596	0.833333
H_{42}	1/S	1/E	0	0.151316	0.163781	0.186404	0.151316

Table A20. Triangular fuzzy comparison matrix of the sub-criteria H_5 and its weights for Chang's approach (EAM), different degrees of optimism in FAHP, and crisp AHP ($CI = 0.038,\ CR = 0.065$).

	H_{51}	H_{52}	H_{53}	ω_{EAM}	$\omega_{\nu=1}$	$\omega_{\nu=0.5}$	$\omega_{\nu=0}$	ω_{AHP}
H_{51}	E	WS	V	0.904283	0.651202	0.644745	0.634569	0.695523
H_{52}	1/WS	E	WS	0.0957168	0.27877	0.281051	0.284647	0.229048
H_{53}	1/V	WS	E	0	0.070028	0.074204	0.080784	0.0754292

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