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Original Research

On the Selection and Quantification of Factors Influencing Sustainable Regional Development

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Abstract

Successful regional development involves the establishment of a sustainable system between natural resources and economic and social challenges confronting the population of a particular area. There are numerous criteria that define these relationships, which can be expressed quantitatively and qualitatively. For a more reliable analysis concerning regional development, mathematical models have been developed based on their quantification and the analysis of multiple criteria to obtain alternative solutions in quantitative form, suitable for a more accurate assessment and ranking in accordance with the advantages and priority of application. This paper provides a model of the choice and quantification of factors that affect the development of the Toplica District, an area with considerable natural resources and a significant lag in its overall development. The objective of this investigation is to evaluate and rank the dominant factors that influence the development of the region under investigation in terms of natural factors (soil, water…), human factors (demographic, qualification, education…), economic factors (agriculture, tourism…), social factors (infrastructure, health…), and environmental factors (land, forest…). The methodology presented here can be used in a modified form for an analogous assessment of the development factors of any other region with similar natural and anthropogenic characteristics.

Keywords: sustainable regional development, development factors, environmental management, quantification, multi-criteria analysis

Introduction

Assessing the progress toward achieving the Sustainable Development Goals (SDGs) has garnered significant attention and investments from both international bodies and national governments [1]. Extensive resources have been allocated to related processes, with plenty of literature dedicated to understanding SDG targets and indicators, largely supported by the United Nations (UN) and national governments [2]. The imperative to establish robust monitoring and reporting mechanisms has emerged

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as a top priority for both the UN system and numerous sub-global administrations [3]. This concerted effort underlines the global commitment to tracking and evaluating advancements toward sustainable development objectives [4]. Since the inception of sustainable development goals in 2015, there has been a continual evolution in methodologies aimed at monitoring progress towards these objectives. Initially, efforts primarily focused on narrowly numerical metrics, but over time, there has been a shift towards more holistic and inclusive approaches [5]. These methodologies have diversified and matured, reflecting a deeper understanding of the multi-aspect nature of sustainable development, particularly in a socially responsible way [6]. Today, a spectrum of monitoring techniques exists, ranging from quantitative indicators to qualitative assessments that consider social, environmental, and economic dimensions. This evolution focuses on the recognition that sustainable development is a complex and interconnected process, requiring comprehensive evaluation frameworks to capture its full scope and impact [7, 8]. Common to the entire process of development of methods for monitoring sustainable development goals is that they predominantly focus on metrics of national importance, while in the scientific literature, there is a limited number of works that focus on the regional or local level of sustainable development. For example, a noteworthy work in which aspects of monitoring sustainable development goals at the local level of a selected urban region in Romania are analyzed, where the focus is on the development and application of an index method for creating a dashboard for SDG achievement summation [9]. In addition to the dominant methods based on the application of composite indices, in contemporary scientific literature, it is possible to identify approaches based on the min-max method as well as the arithmetic mean calculation of selected or derived SDG parameters [10]. In the context of measuring progress toward the Sustainable Development Goals achievement at the regional level, factor analysis can be a valuable tool for analyzing the relationships among various indicators and assessing their collective impact on sustainable development [11]. Factor analysis helps to uncover the underlying structure of the data and to provide the interpretation base for resulting factors. Generally, within this method, the first step is to select a set of indicators that are relevant to the specific SDGs being analyzed. Once the indicators are identified, data is collected from relevant sources, such as national surveys or local development plans (sources in this paperwork). The prepared data is then subjected to factor analysis to identify underlying factors or dimensions that explain the patterns of variation among the indicators [12]. Calculated factor scores provide a summary measure of progress towards each dimension of sustainable development, in the case of this paperwork, Toplica District, where the geographic location of the Toplica district is shown in Fig. 1.

At the level of the Republic of Serbia, monitoring of sustainable development goals is based on the work of the Bureau of Statistics of the Republic of Serbia – SORS, which in its annual reports provides data on most goals, targets, and indicators. Given that these reports do not contain detailed data on regions

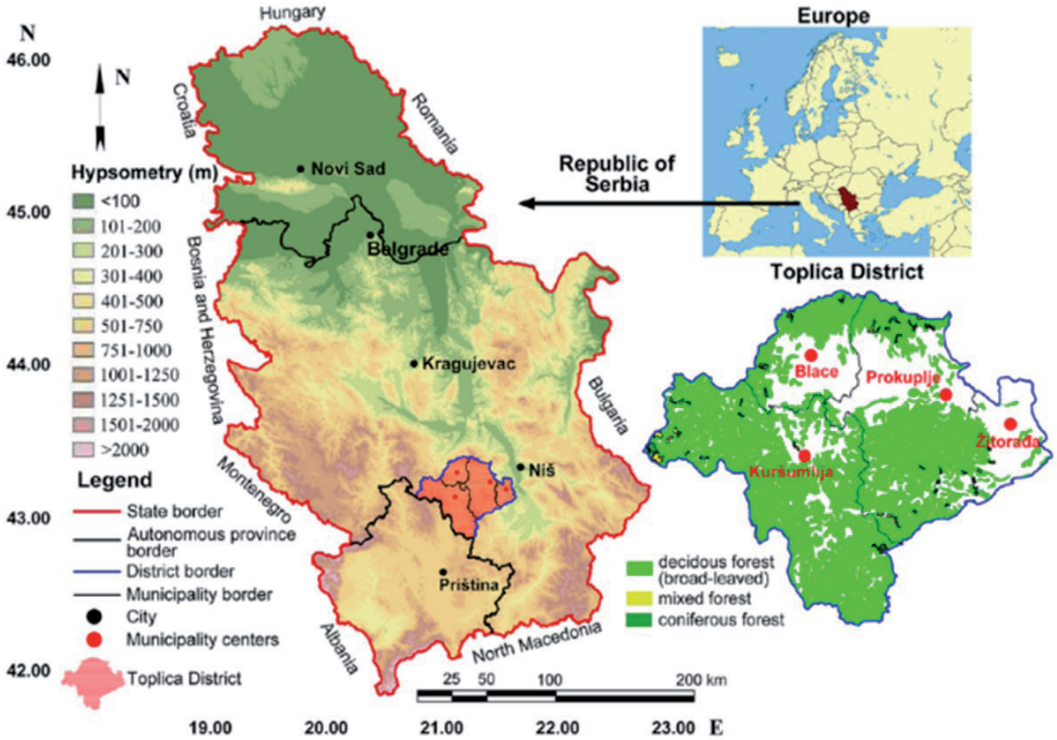

Fig. 1. Geographic location of the Toplica District [13].

or cities, for the purposes of quantification of factors influencing sustainable regional development (in this case Toplica District), the method of factor analysis was applied, where the steps of factor analysis are described in the next paragraph.

The number of influential factors of regional development imposes the need to collect, systematize, and process them both for the region under investigation and for the surrounding environments that affect its development [14]. The collection of data on regional development factors must be designed, organized, and defined through a suitable research program, which includes:

a) Review of the region's development potential and its use based on generally available information on the area,
b) Collection of the data on regional development factors from competent national, regional, and local institutions and directly in the field (by visiting institutions and having discussions with management and management actors in the development of the region and its municipalities),
c) Systematization of collected data by branches, regional and local, as well as by the intensity (size) of their impact on development [15].

After the factors are classified by development groups (natural, human, economic, and environmental factors) and their criteria defined, the data are ranked by importance for regional development, using one of the applicable methods, from inference and induction to statistical analysis [16]. The most influential development factors are certainly those that are ranked higher for each group of factors, and their number is estimated based on previous knowledge about the state, available resources, and users of the regional space [17].

The prominent factors reveal the complexity of the analysis of their unified impact on the definition of regional sustainable development. Multi-criteria analysis proved to be justified and applicable in such situations [18]. For the analysis of the current state and the selection of solutions for sustainable development of the Toplica District in Serbia, a modified factor approach was chosen, which introduces the process of quantification and ranking of collected development factors. This approach is methodologically closely related to a complete systemic approach that analyzes all relevant development factors equally, and even better, it harmonizes more clearly their effects and impact on the selection of the most favorable scenario of sustainable regional development [19, 20].

Material and Methods

Toplica District and Influential Factors for Development

As mentioned in the introduction section, for the purposes of selection and quantification of factors affecting sustainable regional development, a factor approach was chosen, modified by the introduction of a mechanism for quantification and ranking of influential factors of regional sustainable development, identified and classified into five influential groups, each supplemented with relevant sub-indicators (minimum two, for comparison if needed). Each of these groupings has been separately analyzed so that within each of them there are several subgroups of influential factors. The goal of this approach is to obtain data for defining the initial matrix of influential factors that can later be used as input for multi-criteria analysis and deciding on the most favorable future solution for the sustainable development of the Toplica region as an example - a study of regional sustainable development. For the purpose of this research, factor analysis serves as a representative analytical tool in sustainable development by uncovering the intricate relationships among numerous variables. It identifies not-so-easily observed factors that capture the essence of interconnected development variables, thus enabling a concise understanding of complex socio-environmental systems supporting regional sustainable development. In the area of sustainability, this method helps fractionate vast sets of interconnected data into a smaller set of essential factors, facilitating clearer insights into the interplay between environmental, social, and economic dimensions, primarily. By uncovering hidden correlations and reducing redundancy, factor analysis aids in identifying sustainable pathways forward while mitigating the challenge of collinear variables, thereby supporting informed decision-making for a more balanced and resilient future. The applicability of this method is particularly significant from the perspective of the analysis of the influential factors of sustainable development of specific regions but also, at a later stage, of individual units of local self-government, given that in the Republic of Serbia, monitoring of sustainable development goals is done predominantly at the level of the republic [15-19].

Considering modern economic knowledge and practical experience regarding the application of factor analysis in the development of a sustainable regional development strategy, the following groups of influential factors for the Toplica District have been adopted:

– Natural factors (soil, forests, water, mineral raw materials);
– Human factors (demographic, qualification, and educational structure of the population);
– Economic factors (agriculture, processing, forestry, tourism, hunting, and fishing);
– Social factors (infrastructure, health, education, culture);
– Environmental factors (land, forest) [20].

Natural Factors

Soil, forests, water, minerals, and thermal waters are the key natural factors in this area.

Soil as a Development Factor

Of the total area, 95% is covered with agricultural and forested land, on which almost all economic activities of the population (agriculture and processing industry) are conducted. The representation of agricultural land in relation to forested land is greater in the plains and riparian areas of the region, whereas forested land dominates in the mountainous area. The method of processing and utilization preserves the quality and quantity of these soils, which is why this essentially non-renewable resource can be considered an important factor in the sustainable development of the Toplica District [21-24].

Forest Resources

The representation of the forest area of the Toplica District is significantly higher than the national average. The Municipality of Kuršumlija is richest in forested land (about 78%) and wood mass. It is followed by the municipalities of Prokuplje with 67% and Blace with 53%. It is dominated by deciduous forests, which are also the most widely used forest type (about 1.5% of the available forest mass). The rate of restoration of forest resources is several dozen times lower than the exploitation rate. The most unfavorable ratio was found in the Municipality of Blace, where about two percent of the forest mass is exploited without any activities on its restoration. The available forest resources of the Toplica District provide a good basis for the development of the processing industry, especially for the municipalities of Kuršumlija and Prokuplje [21-27].

Water Resources

The main factor in economic and social development and the quality of life of people is water, which is present in all aspects of human activity and in the natural environment. It belongs to the group of natural renewable resources that can change qualitatively and quantitatively in any space over time and through use. The use of these resources in the current conditions of construction of water management facilities along the Toplica River basin is on the verge of sustainability. The connectedness of residents to the public water supply is about 60% (the lowest in the Municipality of Žitorađa – about 26% – and the highest in the Municipality of Blace (90%)), while the connectedness of residents to the sanitation network is even lower (about 50% for the entire Toplica District, the lowest in the Municipality of Žitorađa (22%) and the highest in the Municipality of Blace (67%)). The distribution of water consumption is dominated by water supply to the population (about 60%) and industry (30%). Water consumption for irrigation, mainly in smaller areas, is very low and not even officially recorded. Upon completion, the Selova Regional Water Management System will create the prospect of irrigation of about 25% of higher-quality agricultural land in the riparian areas along the Toplica River [21-27].

Mineral and Thermal Waters

In addition to the preserved natural environment, these resources are important factors in the development of health and recreational tourism in the Toplica District. Prolom Water in the Municipality of Kuršumlija has a commercial status and is classified as water with low mineral content with a slightly higher sodium content but suitable for daily use for drinking and therapeutic purposes, whereas Milan Toplica water in the Municipality of Prokuplje, which has the status of natural mineral water rich in mineral salts, especially fluoride and sodium, is not recommended for daily use for drinking. The spring and the facility for the exploitation of this water have not been operational for years. Thermal waters represent the basis of spa tourism in the Toplica District, especially in the Municipality of Kuršumlija, where all three spa areas are located: Prolom Banja, Lukovska Banja, and Kuršumlijska Banja. Annually, about 30,000 guests stay in these spas, using the healing properties of thermal waters and a high level of health services [21-27].

Human Factors

One of the most important prerequisites for sustainable development of the Toplica District is the availability of human resources. It is primarily characterized by factors of demographic development, age, education, working capacity, and active population structure. The age structure of the population from the aspect of sustainability of development is very unfavorable. At the regional level, nearly 35% of the population belongs to the category of dependents and people over 65. The relationship between the active and working-age population indicates a high unemployment rate (more than 40%) in all municipalities of the Toplica District. The structure of education is dominated by the population with primary and secondary education (over 80%), followed by the uneducated population (6-8%), and the population with college and university education (5-10%) [21-27].

Economic Factors

The most important economic activities in the Toplica District, in which citizens and companies earn their income, are agriculture (farming, livestock breeding, pomology), processing industry (fruit and vegetable, dairy, wood), services (trade, tourism, services), and the state sector (health, education, social security, local self-government bodies). Agriculture is the dominant economic branch not only in the share of national income but also in the labor distribution of residents. On average, about 51% of the population is engaged in agricultural activities – most of them

in the Municipality of Blace 61% and least in the Municipality of Prokuplje 44%. The manufacturing industry follows the agricultural products (fruits, vegetables, dairy, meat) and is mainly found in municipal capitals. It is the second most important activity for the development of the region, with about 35% participation in the training and employment of the population. Tourism and hospitality show considerable development potential for the Toplica District. In addition to spa tourism, natural sites (Đavolja Varoš, forested landscapes on the slopes of Kopaonik, Jastrebac, and Radan mountains, as well as littoral zones around reservoirs near Kuršumlija, Blace, and Prokuplje) can play an important role in the development of recreational, hunting, and fishing tourism. Institutions on the state budget employ about 15% of the active population of the Toplica District, concentrated mainly in municipal capitals and healthcare and educational institutions (e.g., Prokuplje, as the center of the region, is home to about 23% of the active population) [21-27].

Social Factors

The implementation of sustainable development plans is most directly manifested in the living standards and quality of life (QoL) of the residents. For the Toplica District, this can primarily be measured as the achieved level of healthcare of the population, a developed network of educational institutions, and built infrastructure facilities. Basic healthcare is covered through outpatient clinics in all settlements of the region, while primary and secondary care is provided in community health centers in municipal capitals and hospitals in Prokuplje, which is the district capital. The number of doctors per 1,000 inhabitants is lower than the national average (2.9 doctors/1,000 inhabitants) by about 10%, or by 35% compared to EU standards. The most unfavorable situation is found in the Municipality of Žitorađa – 1.1 doctor/1,000 inhabitants [21-27].

Population education is organized for all settlements in 85 primary schools with village outposts, 8 secondary schools located in municipal capitals, and 2 vocational colleges in Prokuplje and Blace. The infrastructure is a particularly important indicator for the overall socio-economic development and quality of life of the population of municipalities and the entire district. It is defined by the construction of the road network, connectedness to the water supply and sanitation network, mail distribution, and IT network. The total length of roads in the Toplica District is 1,190 km, which, in relation to an area of 2,231 km^2, provides a construction indicator of 0.53 km/km^2, which is higher than the national average (0.44 km/km^2). Good connectivity via the road network is a favorable indicator for planning further development of this region. The connectedness to the water supply network of the Toplica District is about 66%, which is lower than the national average (77%), and there is a lag in the construction and connectedness to the sanitation network in almost all settlements of the region.

The mail distribution and IT networks are mostly available in all settlements [21-27].

Environmental Factors

The activities related to environmental resource processing in the Toplica District that impact the environment the most include land use, water use, forest exploitation, and disposal of municipal solid waste. Agricultural land is the basis for food production, and farming is the activity practiced by more than half of the working-age population. The land comprises a rather large number of small plots (about 3 hectares per household) and is mostly unprofessionally farmed, which negatively affects agricultural production itself as well as the structure and quality of land and water and the survival of specific living communities. Water is an important factor in the sustainable development of the Toplica District. The cleanest waters are located in the upper (mountain) parts of the Toplica river basin and are reserved or already distributed for organized water supply to the population (larger rural clusters and municipal capitals). Using such a methodology, about 60% of the population is supplied with specific consumption (98 l/inhabitant/day), which is less than the basic consumption norm (150 l/inhabitant per day). A bigger problem throughout the area is the undeveloped sanitation systems and wastewater discharged into the nearest waterways or underground without any prior treatment. The water quality in these watercourses downstream from the settlements is degraded and fails to meet the prescribed norms defined by the law. The forest resources of the Toplica District are characterized by ownership division between the state (63%) and private entities (37%), and according to the Law on Forests, they are managed according to the management program adopted at the proposal of the competent Ministry, as adopted by the Government of the Republic of Serbia. Such a program exists only for state forests, while for private ones, special annual management plans are made. Privately owned forests are extremely fragmented, making it difficult to adopt and implement their management plans. As for the use of these resources, there is a significant deviation from the strategically set goal in Serbia, viz., to establish a balanced relationship in the use of forests between exploitation and afforestation. This ratio is very unfavorable for the Toplica District (93% versus 7% in favor of exploitation). About 1.5% of the available forest mass is exploited annually. Waste disposal and management pertain to a group of factors that increasingly threaten the natural environment of the Toplica District. All municipal capitals, including settlements in their immediate vicinity, organized waste collection, but without resolving the issue of sanitary disposal and recycling. Existing landfills and their equipment are more suited to the category

of garbage dumps than landfills. This type of waste treatment involves 50% of the population, while the rest of the waste is deposited uncontrolled outside of these locations [21-27].

Results and Discussion

Evaluation of Factors Influencing the Development of the Toplica District

Sustainable development of regional and local communities involves establishing a balance between economic, social, and environmental factors of development [28-30]. Some of these factors are measurable, i.e., can be quantified and numerically expressed, while with non-measurable factors, the researchers have evaluated their value and ranked significance based on experience and supplementary knowledge [31, 32]. The scope and clarity of these factors also impose the need for their use in accordance with the importance and impact on the further development of the region. Considering this as a backdrop, twelve of the most influential factors of development of the region were adopted for the Toplica District, classified into four groups: natural, human, economic, and environmental factors of development.

Natural Factors

Fragmented parcels of agricultural land, measured by economic indicators, can be considered developmental and sustainable resources in agriculture only if the measures of joint market-oriented production are implemented together with the improvement of agricultural production. Previous experience in the use of agricultural land indicates that [33-35]:

– Owners of agricultural land up to 3 hectares of property size have and will have problems with their livelihood only if they make a living from agriculture on their property. They need additional activity or reorientation to more intensive production of vegetable crops,
– Agricultural households with ownership of over 10 hectares can evolve into carriers of market agriculture, not rural production.

Forested land, in terms of expanse and average plot size, dominates over agricultural land, especially in the municipalities of Kuršumlija and Prokuplje, as shown in Table 1.

The available area and exploitation and restoration of forest resources are the starting elements for the evaluation of forests and forested land as factors of sustainable development and environmental protection of the Toplica District.

The water resources of the Toplica District consist of surface and groundwaters located around the Toplica river basin, whose boundaries are fully aligned with the boundaries of the district. Water demand is normally defined as the volume of water that a resident requires for a day, specifically for the production of one unit of product as well as for irrigation per m^2 (ha) of agricultural surface area. According to the existing standards, a minimum of 150 liters per inhabitant per day is required for one resident, 3-6 liters of water for processing 1 liter of milk, and approximately 3,000 m^3/ha per year for irrigation. The percentage of compliance with these standards towards residents was adopted as a value factor in the field of water management.

Human Factors

The Toplica District is affected by long-standing depopulation, with increasingly uneven spatial distribution and unfavorable age and working age structures. All these unfavorable circumstances can be considered as influential factors of development, of which the state of the working age and active population and its educational structure are the most prominent.

According to the indicators from the Tables 2 and 3, there are noticeable similarities in demographic characteristics among municipalities of the region. For sustainable development, priority is given to capable and active populations and their education and qualifications.

Table 1. Land as a factor of sustainable development in the Toplica District.

Land	Land (ha)			Development factor (ha/home)	
	Agricultural	Forest	Number of households	Agricultural land	Forested land
Municipality					
Kuršumlija	14,127	52,361	3,742	3.78	13.99
Blace	10,339	11,674	3,255	3.18	3.59
Prokuplje	17,789	35,485	5,548	3.21	6.40
Žitorađa	9,297	3,178	3,767	2.47	0.84
Toplica District	51,553	102,698	16312	3.16	6.30

Economic Factors

One of the limiting factors of development may be the number, structure, and ability of the active population to respond to future economic challenges while ensuring the conditions for sustainable development by accompanying non-economic activities and the security of the dependent part of the population. For this reason, it was established that the working-age population should be a factor in economic development. The value of this factor is defined by the corresponding indices or coefficients where:

1. The load coefficient of the working-age population is defined as the ratio of the number of inhabitants over 65 and the number of working-age population. It is considered viable when its value is less than 1,0.

2. Economic Sustainability Index I represents the relationship between the working-age population in agriculture, as the primary branch of industry, according to the active population working in services, and it should be higher than 1,0.

3. Economic Sustainability Index II is defined as the relationship between the working population in agriculture, the manufacturing industry, and the service sector, according to the number of inhabitants working in state-financed institutions. It is considered viable if its value is not less than 5.

4. The coefficient of sustainability defines the ability of the working-age population's age structure to keep up with economic activities in the municipality and the

Table 2. Population as a factor of sustainable development in the Toplica District.

Population	Demographic structure				Indicators		
Municipality	Number of inhabitants	Working age population	Active population	Unemployed population	Age index	Unemployment (%)	Development factor: Active inhabitants (%)
Kuršumlija	19,213	12,650	7,052	5,598	1.28	44	36.7
Blace	11,754	7,283	4,001	3,282	1.77	45	34.0
Prokuplje	44,419	29,413	15,062	14,351	1.22	49	33.9
Žitorađa	16,368	10,286	5,593	4,693	1.34	46	34.2
Toplica District	91,754	59,632	31,708	27,924	1.40	47	34.6

Table 3. Education of the population as a factor of sustainable development in the Toplica District.

Population	Working age (Y)	Education – weight factors ($Y \times K_i$)						Development factor: Level of education
Municipality		Without (K = 1)	Elementary (K = 2)	Secondary school (K = 3)	College education (K = 4)	Higher education (K = 5)	Total ΣYxK	
Kuršumlija	16,401	1,019	12,840	22,068	2,832	4,490	43,249	2.64
Blace	10,294	832	7,498	13,926	2,068	2,770	27,094	2.63
Prokuplje	37,526	1,729	26,036	53,331	9,208	13,500	103,804	2.77
Žitorađa	13,826	1,033	13,100	16,680	1,580	1,440	33,833	2.45
Toplica District	78,047	4,613	59,474	106,005	15,688	22,200	207,980	2.66

Table 4. Economic activity of the population as a factor of sustainable development in the Toplica District.

Population	Employment by activity				Development factors			
Municipality	Agriculture, Industry	Services	State budget	Total active population	Coefficient of efficiency	Sustainability index I	Sustainability index II	Sustainability coefficient
Kuršumlija	1,272	1,121	1,391	3,784	0.284	1.135	1.720	0.85
Blace	739	736	723	2,198	0.416	1.004	2.040	0.74
Prokuplje	4,074	2,806	3,664	10,544	0.283	1.452	1.766	0.88
Žitorađa	301	413	569	1,283	0.350	0.729	1.347	0.89
Toplica District	6,386	5,076	6,347	17,809	0.314	1.258	1.806	0.85

district. It is defined as the relationship between working age groups aged 15 to 40 and groups aged 41 to 65. It is considered viable when it is not less than 1,0.

The values of economic factors are given in Table 4.

Social Factors

The assessment of the effects of economic development is measured according to their contribution to improving the standard of living and the living conditions of the population. Health insurance, education, and infrastructural equipment are some of the most important indicators of achieved social development in an area, which was also adopted for the Toplica District. Their measurability and evaluation are defined by the achieved results in the built facilities of common interest as well as in the services provided with the aim of improving the health, educational, cultural, and overall living standards of the inhabitants, as shown in Table 5.

Natural Factors

Natural resources are not only the main factors in the development of the Toplica District but also its most important elements of sustainability. Land, forests, and water are directly affected by the population and can usually be controlled via restrictions defined by relevant norms and standards. The attitude of the inhabitants towards these restrictions was adopted as a determinant for defining the factors of environmental quality maintenance.

Sustainable Development of the Toplica District – Planning and Decision Elements

Planning the development of the Toplica District based on the principle of sustainability involves monitoring its influential factors simultaneously influencing the development. The number and value of these factors highlight the need to use some of the mathematical methods of multi-criteria analysis

Table 5. Social standard of the population as a factor of sustainable development in the Toplica District.

Municipalities / Social standard elements	Kuršumlija	Blace	Prokuplje	Žitorađa	Toplica District
	General data				
Population	19,213	11,754	44,419	16,368	91,754
Number of settlements	93*	40	107	30	270
	Healthcare				
Number of doctors	34	19	165	17	235
Development factor (standard)	1l/565ppl = 0.0018	1l/618ppl = 0.0016	1l/269ppl = 0.0037	1l/963ppl = 0.0010	1l/390ppl = 0.0026
	Education				
Primary education (number of schools)	14	19	32	20	85
Development factor (school density)	14/90 = 0.16	19/40 = 0.48	32/107 = 0.3	20/30 = 0.67	85/270 = 0.32
Secondary education (number of schools)	2	1	4	1	8
Development factor (school density)	2/90 = 0.22	1/40 = 0.025	4/107 = 0.037	1/30 = 0.033	8/270 = 0.030
Higher education (number of schools)	-	1	1	-	2
Development factor (school density)	-	1/40 = 0.025	0.009	-	0.007
	Infrastructure				
Length of roads (km)	556.85	200.20	339.57	94.00	1190.68
Development factor (construction km/cap)	556.85/19213 = 0.029	0.017	0.008	0.006	0.014

*Three settlements are without inhabitants.

in planning and monitoring the development of the region. The results of the research are summarized and presented in Table 6.

The starting point for the application of these methods is the definition of the initial decision matrix, with elements determined according to the presented methodology for the selection and quantification of factors influencing the sustainable development of the Toplica District.

According to the obtained data, it can be clearly concluded that regional sustainable development is a complementary set of complex contributions (in relation to the analyzed factors of development in the work), where the final result is seen, first of all, as the result of multiple interactions between demographic, ecological, economic, and other variables. From a demographic and sociological point of view, dynamic processes within the analyzed populations have a significant impact, where the most significant influence of the level of education (K3) was identified in all local governments (where this factor was evaluated with the greatest impact in the example of Prokuplje – 2.630, which is probably the result of the fact that Prokuplje is an administrative and educational center of Toplica district). On the other hand, the age index (K1) is in second place in terms of influence on regional sustainable development, where this factor is the most significant in Blace - 1,890. The load coefficient of the working-age population (K2) was not identified as a particularly important element of sustainable regional development, especially in the municipality of Kuršumlija, with a value of 0.284. In addition to the analyzed factors, migration patterns can also affect the capacity of the region to maintain ecological balance and sustainable use of resources. For example, high population growth rates can strain resources and infrastructure, posing a challenge to sustainable development.

The analyzed environmental factors represent the basic determinant of sustainable regional development, which includes consideration of available agricultural land (K10), degree of forest exploitation (K11), and degree of water use (K12). In this domain, the contribution of the use of water resources is especially highlighted in the example of the municipality of Žitoradja, where there is even excessive exploitation of available water resources (121%), which means that in a certain future period, without adequate interventions, this municipality will lead to excessive use of water resources, i.e., to a degraded or unavailable state. In the context of the exploitation of forest resources, their contribution is relatively small at the level of all analyzed settlements, while available agricultural land is at the average level in the Republic of Serbia. In addition to these factors, the ability of the region or the observed cities to adapt to climate change is crucial for sustainable development. In this sense, future policies dealing with adaptation, resource substitution, and prevention of ecosystem degradation (due to climate change) are

Table 6. Initial decision matrix for sustainable development in the Toplica District.

Variants (municipalities) / Criteria		V1 Kuršumlija	V2 Blace	V3 Prokuplje	V4 Žitorađa
I Demographics – population					
K1 Age Index	Min.	1.284	1.890	1.230	1.383
K2 Load coefficient of the working-age population	Min.	0.284	0.416	0.283	0.350
K3 Level of education	Max.	2.510	2.480	2.630	2.260
II Economic activity					
K4 Economic Sustainability Index I	Min.	1.135	1.004	1.452	0.729
K5 Economic Sustainability Index II	Max.	1.720	2.040	1.766	1.347
K6 Sustainability coefficient	Max.	0.830	0.740	0.880	0.890
III Social Standard					
K7 Education, density of primary and secondary school (school/teacher)	Max.	0.1777	0.5000	0.3364	0.7000
K8 Standard of healthcare (doctor/resident)	Max.	0.0018	0.0016	0.0037	0.0010
K9 Degree of road construction (km/resident)	Max.	0.0290	0.0170	0.0080	0.0060
IV Environment					
K10 Available agricultural land (ha/household)	Max.	3.73	3.12	3.17	2.44
K11 Degree of forest exploitation (%)	Min.	1.26	1.66	1.40	0.70
K12 Degree of water use (%)	Min.	35	44	55	121

imperative to mitigate negative climate impacts within all observed settlements.

Based on the analysis, it is noticeable that both economic and social dimensions contribute significantly to regional sustainability. In this sense, the structure and diversification of the economy, employment patterns, and education aspects directly affect the well-being of the population and sustainable regional development. In this part, it is noticeable that the diversification of the economy in the context of economic sustainability index I (K4) is unsatisfactory in Žitoradja (0.729) and at the limit of sustainability in Blace (1.004), while the variable economic sustainability index II (K5) is unsatisfactory in all observed municipalities, considering that everywhere it records a lower value of 5. Of the other analyzed variables in the domain of environmental and social dimensions, it is important to note the relatively small contribution of healthcare standard (K8) at the level of all municipalities, while the level of education (K7) is sufficiently significantly represented as an influential factor in all municipalities (where the leader is Žitoradja with a recorded 0.700 score). Among the other factors, it is important to take into account the resilient and inclusive economy, where the importance of diversification is already partially shown by the variable economic sustainability index II – K5).

Similar examples of assessment and interpretation of regional sustainable development factors can be found in contemporary publications. Thus, for example, after a similar analysis, natural resources and human capital are recognized as the backbone of sustainable regional development, with a note that excessive exploitation of natural resources can have a cascading negative effect on natural ecosystems and economic entities [36]. On the other hand, by applying factor analysis in the domain of urban agglomerations, it was concluded that urban planning, management, and design have a key role in regional sustainable development [37].

The conclusions of the factor analysis conducted on the example of developed and underdeveloped countries are extremely interesting, where it was concluded that developed nations derive the greatest advantages from emphasizing social and environmental factors while developing nations benefit most from their emphasis on economic and social factors [38].

In any case, achieving a harmonious balance between economic growth and environmental protection requires the promotion of sustainable concepts of regional development, with a focus on the transition to green technologies and socially responsible business. In this sense, a science-based approach to regional sustainable development requires a comprehensive analysis and integration of demographic, ecological, and economic factors to design effective policies and strategies for regional sustainable development.

Conclusions

The modern approach to sustainable regional development is based on a territorial approach, in which a certain territory is the primary focus, with all the specifics essential for its recognition and planning. A large number of factors and their varying degree of measurability of impact on development require a more detailed analysis and selection before using factor and multi-criteria analysis of regional development. In this sense, the presented factor analysis method is particularly important for the issues of national, regional, and local plans for sustainable development for the sake of underlying relationships among numerous variables by grouping them into factors based on their correlations. At the national level, factor analysis can help in formulating national policies that target the most influential factors for national sustainable development. For regional and local plans, factor analysis can identify specific factors relevant to different areas. This is essential because sustainable development challenges and priorities can vary significantly across regions and localities. For example, a coastal region might prioritize marine conservation and sustainable tourism, while an urban area might focus on reducing air pollution and improving public transportation. In an analog way, by understanding the underlying factors that drive sustainability, governments and organizations can allocate resources more efficiently. With no less importance is the fact that regional sustainable development plans require ongoing monitoring and evaluation to assess their effectiveness.

Factor analysis aids in developing comprehensive monitoring frameworks by identifying key indicators that need to be tracked over time. This allows for the measurement of progress and the adjustment of strategies as needed. From the stakeholder's perspective, incorporating factor analysis into the planning process promotes data-driven decision-making. It ensures that decisions are based on empirical evidence rather than intuition or subjective information. The presented factor analysis approach enhances the credibility and effectiveness of sustainable development actions. In a regional context, such as a district level, factor analysis might reveal that agricultural productivity and access to clean water are the most significant factors. Thus, regional plans can focus on sustainable agricultural practices and improving water management systems. Also, factor analysis can highlight the interconnections between these sectors, facilitating a more integrated approach to planning and implementation. For instance, it can reveal how improvements in education can lead to better health outcomes and economic opportunities, fostering a holistic regional development strategy.

In summary, as sustainable development insists on the comprehensiveness of participation and greater responsibility of all actors of local self-government in its implementation, researchers are allowed to take advantage of this in all stages of their work, from

the project task through the research program to the final results of the research, and to transparently check their theoretical and practical knowledge in the selection of factors influencing regional development. This possibility was used in practice through the presented methodological procedure in the selection and quantification of sustainable development factors for the Toplica District. The obtained results of the conducted procedure confirmed its correctness and the necessity of obtaining the initial matrix and multi-criteria analysis and decision-making for further development of the Toplica District.

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Conflict of Interest

The authors declare no conflict of interest.

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