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STRATEGIC ASSESSMENT OF THE IMPACT OF INDUSTRIAL AND ECONOMIC ACTIVITIES IN THE DEVA-HUNEDOARA CONURBATION USING THE RIAM METHOD

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ABSTRACT. Deva-Hunedoara conurbation is a bipolar structure located in central-western Romania composed of 49 settlements. It is located in the center of Hunedoara County. The long history of industrial activities in the area resulted in an abundance of environmental impacts which has significant negative consequences on the local population. Intense industrial activity, regarded as the base for the urban development of the conurbation, dates back to the 1840's when the first steel mill was constructed in the region.

The main sources of environmental impact are represented by the decaying industrial centres of Hunedoara, Simeria and Călan and the newly developed industrial sites located on the major transport networks. A secondary source of environmental impact is represented by the various small enterprises.

Coupled with various other human activities and with the general state of the environment, the impact generated by industry and other economic activities represents a great threat to overall development of the conurbation.

In assessing the environmental impact on within the conurbation we proposed the use of the RIAM method with a modified matrix which is best suited for our area of study. With this matrix we assessed the environmental impact of industrial and commercial areas, transportation and utility systems and several other aspects related to human activities (health and safety, unemployment, human density, etc.). For the final interpretation of the environmental impact we used the IDWIM - Inverse Distance Weight Interpolation Method to generate maps of impact.

Key words: *conurbation, RIAM, matrix, environmental impact, industrial area.*

INTRODUCTION

Environmental impact assessment can be performed by multiple methods and techniques derived from numerous scientific disciplines. Among the most used methods are the matrices. The major use of matrices is to indicate cause and effect by listing activities along the horizontal axis and environmental parameters along the vertical axis. The simplest matrices use a single mark to show whether an impact is predicted or not. However it is easy to increase the information level by changing the size of the mark to indicate scale, or by using a variety of symbols to indicate different attributes of the impact. The greatest drawback of matrices is that they can only effectively illustrate primary impacts.

One of the cheapest, fast and well tested matrices is Leopold's matrix. This matrix creates the connection between environmental factors and human activities and ensures that no type of user impact has been omitted. Assessment of magnitude and importance of impacts involves partially subjective judgments, which diminishes the accuracy of knowing those beneficial and adverse impacts (Leopold et al., 1971). The Leopold matrix was conceived by geologist Luna B. Leopold and his colleagues in 1971, as a response to the US Environmental Policy Act of 1969, which didn't give clear instructions to the Federal Government agencies for preparing an impact report or for examining the environmental effects of the projects that an agency plans. According to the Leopold matrix method, EIA should consist of three basic elements: listing of the effects on the environment; evaluation of the importance of each of listed effects; a summary evaluation, which is a combination of magnitude and importance estimates.

The best adaptation of Leopold's matrix is the RIAM method (Rapid Impact Assessment Matrix) developed by the Pastakia and Jensen. The RIAM method essentially preserves Leopold's matrix structure but offers the possibility of restricting the number of analyzed components. RIAM is a matrix method developed to bring subjective judgments in a transparent way into the EIA process. The method was developed by Cristopher Pastakia (Pastakia and Jensen, 1998) at the end of the 1990s, and since then it has been widely tested in many assessment situations and case studies. RIAM is based on the standard definition of concepts used in the EIA process. With the help of the method different impacts and their significance can be evaluated using commonly defined criteria, each of which has its own ordinal scales. The results of the assessment are placed on a simple matrix, which leaves permanent and reasoned records about the judgements made. In the original RIAM method five evaluation criteria are used, namely impact importance (A1), magnitude (A2), permanence (B1), reversibility (B2) and cumulatively (B3) (Pastakia, 1998).

METHODOLOGY AND RESEARCH AREA

Out of the existing industrial and economic activities in Deva-Hunedoara conurbation, the current paper analyses only the most important and significant components with RIAM – Rapid Impact Assessment Matrix.

RIAM methodology applied in this study complements earlier stages (field research) of the impact assessment enabling a broader approach in the context of human pressures on the environment. In this context, environmental impact assessment is seen as a procedure designed to ensure that potential significant environmental impacts are assessed satisfactory and are considered in the planning, design, approval and implementation of all relevant types of human activities (Glasson et al., 1994).

The adaptation the method and matrix's components were performed taking into account the environmental specificities of the studied territory and their anthropogenic significance. The evaluation is based on official information and detailed observations made in the field, which allows an increase in the objectivity of the assessment itself.

As shown in table 1 the considered economic activities mainly relate to: health, transport, utility networks, population density, waste management and industrial areas. Depending on the specificity of each of them, these activities cause various impacts, which determine that in some areas the presence of economic activities is evident, while in other less significant. For example, on industrial sites, activities have a more obvious impact compared with transport activities.

Table 1. *Analyzed components*

Economical and Operational Components				
Human Health and Safety	Unemployment Rate	Tourism	Population Density	Waste Storage
Transport Networks	Utility Networks	Residential Areas	Commercial Areas	Industrial Areas

Table 2. *Classification and description of categories of environmental impact based on assessment scores*

Environmental Score	Impact Categories	Category Description
over +101	+E	Major Positive Changes / Impacts
+76 la +100	+D	Significant Positive Changes / Impacts
+51 la +75	+C	Moderate Positive Changes / Impacts
+26 la +50	+B	Positive Changes / Impacts
+1 la +25	+A	Slightly Positive Changes / Impacts
0	N	Lack Change of the Status Quo / Not Applicable
-1 la –25	-A	Slightly Negative Changes / Impacts
-26 la –50	-B	Negative Changes / Impacts
-51 la –75	-C	Moderate Negative Changes / Impacts
-76 la –100	-D	Significant Negative Changes / Impacts
under -101	-E	Major Negative Changes / Impacts

In order to determine the environmental impact of each component analyzed, the fallowing formulas are used:

(A1) x (A2) = (At) (1);
(B1) + (B2) + (B3) = (Bt) (2);
(At) x (Bt) = (SE) (3); where SE is total evaluation score.

Finally, based on the evaluation scores and notes obtained (factorial and total) impact categories are created (table 2).

Graphical representation of impacts (sectorial and general) was done using ArcGIS 10 software, specifically with IDWIM - Inverse Distance Weight Interpolation Method. The method is based on the principle that the magnitude of the impact is directly proportional to the source location of impact. This method literally takes the concept of spatial autocorrelation, based on the presumption that the more a standard point is closer to the place to be determined, the value to be determined will be closer to standard point value (IDW - Spatial Analyst ArcGIS Resource Center).

Also, the IDW method determines individual values for each cell using a point system whose “weight” and role in the interpolation varies linearly starting from a set of determined point values. The values for each cell are estimated from the average value of the sampling points in the vicinity of each cell (Lu and Wong, 2008; Shougeng et al., 2013; Mueller et al., 2004). Because this method is based on the average values of sample points and the distance between them, the result cannot include values greater than the maximum or lower than the minimum.

This method is best suited when it is applied to a dense network of points, as is our case with 49 locations distributed over 420 square km. In order to reach objective results based on existing methodology we used a formula for weighting locations based on their rank in the settlement system of the conurbation. The final impact score (FIC) resulted after the application of the formula:

$$FIC = SE \times (10-R/10);$$

where: SE = impact score; R = settlement rank; 10 = constant

Deva - Hunedoara conurbation is a bipolar structure located in central - western Romania. In the county of Hunedoara the conurbation is located at the confluence of Cerna and Mureş rivers, at the contact the four major geographical units: in the north Apuseni Mountains with subdivision Metaliferi Mountains, in the west Poiana Ruscă Mountains, in the south the Haţegului Depression and in the east the Orăştiei hills (Dobrei, 2013). Deva - Hunedoara conurbation is formed by the union of 49 settlements, 4 towns and 45 villages (table 3).

Table 3. *Statistical data of Deva-Hunedoara conurbation*

Administrative Unit	Number of Settlements	Population in 2002	Administrative Surface (sq. km)	General Density (inh. /sq. km)
Deva	5	69257	61.85	1119.75
Hunedoara	6	71257	104.05	684.83
Simeria	7	13895	48.59	285.96
Călan	13	13030	93.54	139.22
Băcia	4	1797	29.04	61.88
Peştişu Mic	9	1290	49.95	25.82
Cârjiţi	5	798	45.82	17.41
Total	49	171324	432.84	395.81

From a hierarchical point of view the top position is occupied by Deva, Hunedoara occupies the second place, Simeria and Călan share the 3rd position while the remainder of 45 settlements are spread out over another 4 ranks. Given the high number of urban settlements in the area and considering the fact that most economic and industrial activities are located in urban areas we have decided to also apply RIAM to the urban areas. In doing this we divided each of the 4 urban settlements in 5 zones with similar characteristics and analyzed each separately.

RESULTS

As expected, the vast majority of results are located in the negative scale (47 out of 49) (table 4). This is due to intense urbanization and industrialization of the area which created intense anthropogenic pressure on the analyzed components. The lowest score is recorded in Călan (-86) while the only two positive results are registered in Cîrjţi and Mânerău (+2). Major deficiencies in Waste Storage, Utility and Transport Networks, high Unemployment Rate, abandoned or poorly structured industrial areas are the main causes of the high negative impact scores.

The graphical representation from figure 1 reveals in a clear and suggestive manner the distribution of the environmental impact in the conurbation. We observe a clear clustering: significant negative, negative and moderate negative results tend to cluster along the Călan – Hunedoara – Peştişu Mare – Cristur – Deva alignment, slightly negative and slightly positive results on the other hand tend to occupy the western and eastern (rural) parts of the territory.

Clustering of the major negative impacts in the central of the conurbation is a consequence of the positioning of major economic, industrial and transportation activities along the main lines of force of the territory.

Comparing the results obtained for each of the 4 urban centers, shown in table 5 and in figures 2, 3, 4 and 5 we conclude the fallowing: in the central area/CBD of each city we encountered numerous and varied activities, thus the varied scores from -32 to -1; on average environmental impact in house residential areas is lower than in apartment residential areas; the lowest impacts are recorded in the ecological/ recreational areas (from -9 to +2) do to strict control of activities and low human density; in the dedicated industrial/commercial areas we have registered the biggest impact scores (-7 to -33); in Deva and Simeria the transport activities have the biggest impact while in Călan and Hunedoara the biggest impact is generated by the steel industry.

Table 4. *RIAM method - Economical and Operational Components*

Name	Impact Score	Impact Class	Name	Impact Score	Impact Class
Deva	-69	-C	Mânerău	+2	+A
Hunedoara	-57	-C	Nădăştia de Jos	-6	-A
Simeria	-56	-C	Nădăştia Sus	-6	-A
Călan	-86	-D	Nandru	-10	-A
Almaşul Mic	-12	-A	Ohaba Streiului	-8	-A

Name	Impact Score	Impact Class	Name	Impact Score	Impact Class
Almaşul Sec	-14	-A	Peştişu Mare	-31	-B
Archia	-3	-A	Peştişu Mic	-9	-A
Băcia	-3	-A	Petreni	-8	-A
Bârcea Mare	-23	-A	Popeşti	-6	-A
Bârcea Mică	-19	-A	Răcăştia	-17	-A
Batiz	-11	-A	Sâncrai	-9	-A
Boş	-10	-A	Sântămăria de Piatră	-5	-A
Călanu Mic	-16	-A	Sântandrei	-12	-A
Cârjiţi	+2	+A	Sântuhalm	-26	-B
Cărpiniş	-8	-A	Săuleşti	-17	-A
Chergheş	-8	-A	Simeria Veche	-26	-A
Ciulpăz	-3	-A	Strei	-5	-A
Cozia	-12	-A	Strei-Săcel	-6	-A
Cristur	-11	-A	Streisângeorgiu	-10	-A
Cutin	-10	-A	Tâmpa	-22	-A
Dumbrava	-6	-A	Totia	-3	-A
Grid	-7	-A	Uroi	-10	-A
Groş	-6	-A	Valea Nandrului	-9	-A
Hăşdat	-12	-A	Valea Sângeorgiului	-8	-A
Josani	-9	-A			

Table 5. *RIAM - Economical and Operational Components in urban areas*

	Deva		Hunedoara		Simeria		Călan	
	impact score	**impact class**	**impact score**	**impact class**	**impact score**	**impact class**	**impact score**	**impact class**
central area/CBD	-32	-B	+1	+A	-12	-A	-20	-A
residential area (houses)	-18	-A	-5	-A	-8	-A	-16	-A
industrial/commercial area	-7	-A	-33	-B	-31	-B	-20	-A
residential area (apartments)	-10	-A	-26	-B	-7	-A	-21	-A
ecological / recreational area	-2	-A	+6	+A	+2	+A	-9	-A

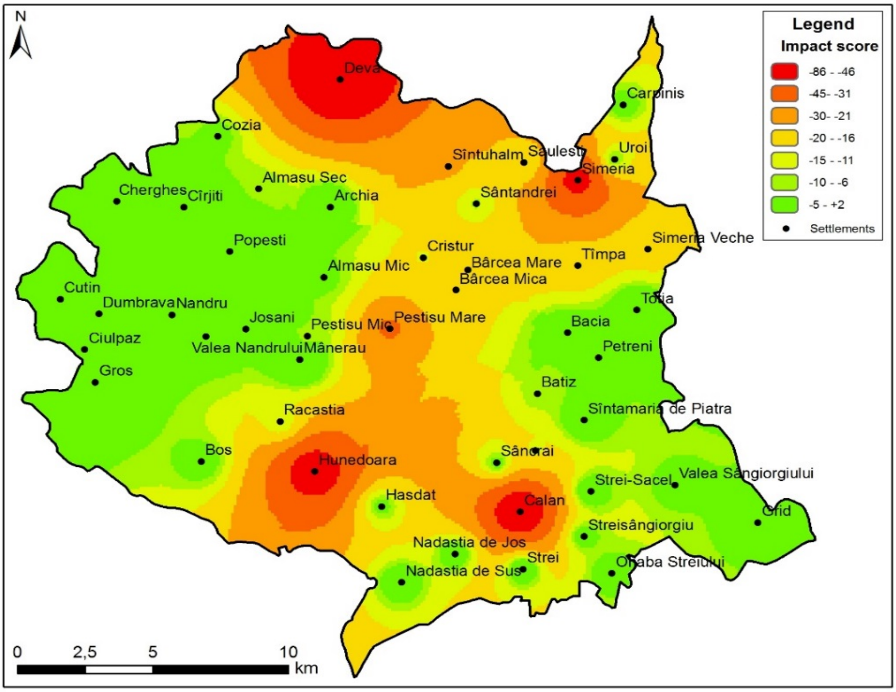

Fig. 1. *Environmental impact – IDWM – Economical and Operational Components*

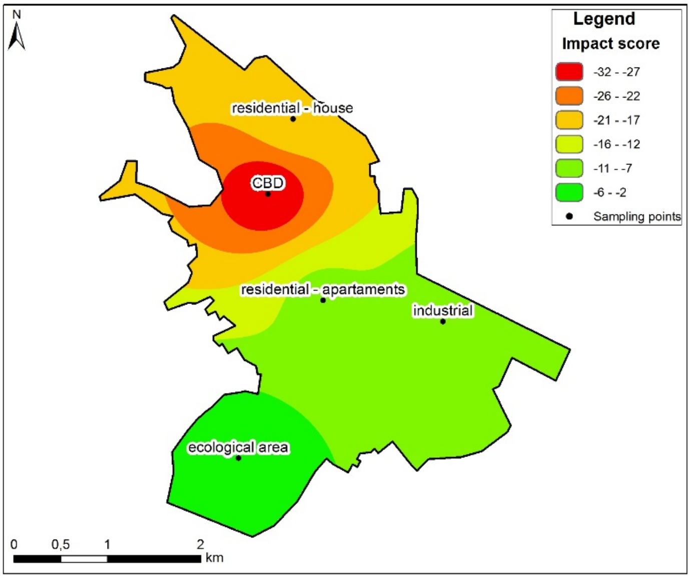

Fig. 2. *Environmental impact – IDWM – Economical and Operational Components in Deva*

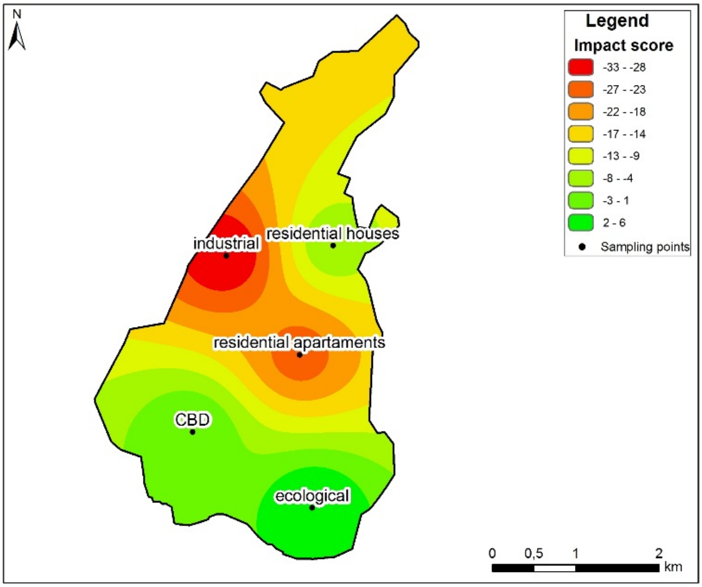

Fig. 3. *Environmental impact – IDWM – Economical and Operational Components in Hunedoara*

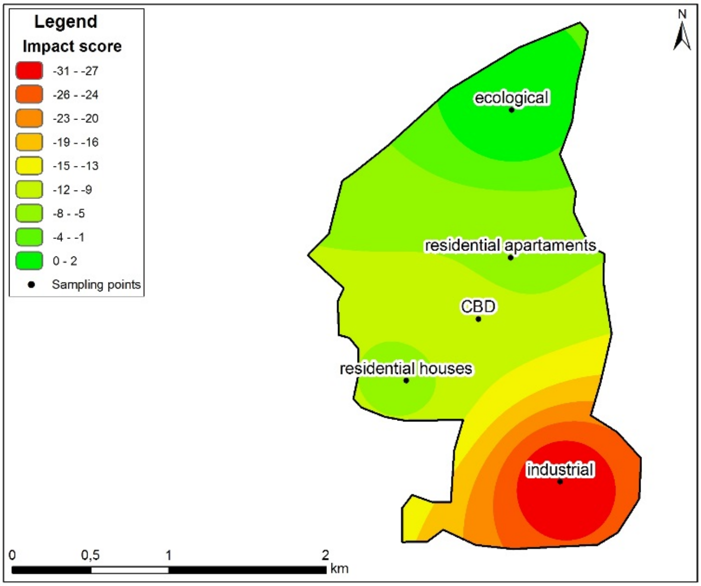

Fig. 4. *Environmental impact – IDWM – Economical and Operational Components in Simeria*

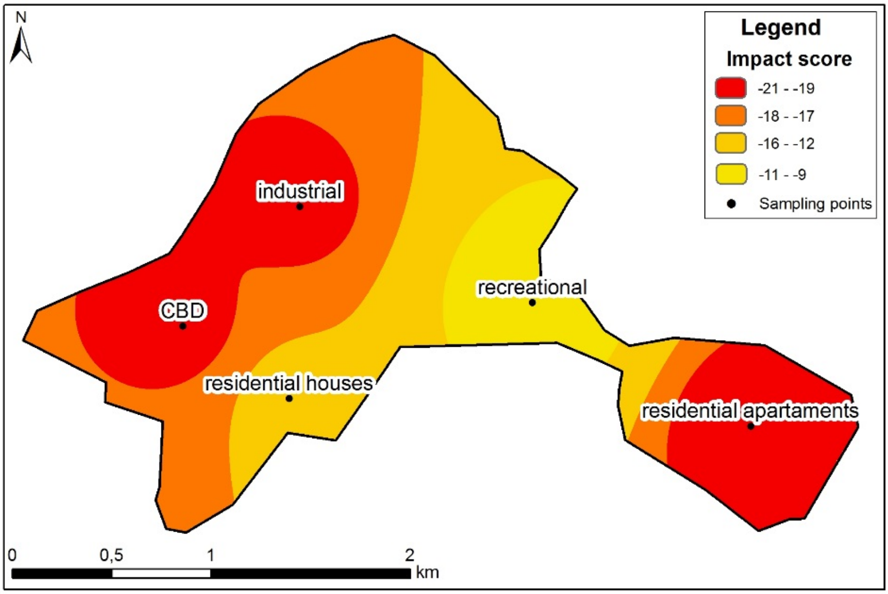

Fig. 5. *Environmental impact – IDWM – Economical and Operational Components in Călan*

CONCLUSIONS

RIAM and IDWM applied as the last stage of the Environmental Impact Assessment study generates satisfactory results given that the prior stages (fieldwork, documentation, physical-chemical analyses) are conducted with responsibility and precision.

The flexibility offered by RIAM in choosing the components analyzed allows this method to be successfully applied to multiple areas of study. In our case it proved to be the ideal method combining the authors knowledge of the area with data gathered from local and regional authorities. The method was easily and quickly adapted to the area's particularities.

The graphic representation performed with IDWM further enhanced the results obtained with RIAM by adding weight to the impact point. Maps created with this method are suggestive and easily understandable.

The limitations of the method are well known and discussed and refer to the subjectivity of the person applying the method. We consider that the authors meticulous and varied information gathering process combined with some of the results being validated by local experts created a high degree of subjectivity in this study.

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