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STRATEGIC ASSESSMENT OF THE ENVIRONMENTAL IMPACT IN DEVA-HUNEDOARA CONURBATION USING RIAM METHOD – PRELIMINARY RESULTS

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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 at the crossroad of major transport networks. With a remarkable diversity of natural factors and a high share of human and economic activities, the area creates different types of impacts on the environment. The potential impacts derive from the rich industrial activity, day to day human activities, transport, commerce, constructions, etc.

In assessing the environmental impact within the conurbation we used the RIAM method with a modified matrix, suited for our area of study. For each of the 49 settlements we analyzed the environmental impact of 37 components coupled in 4 major categories: physical and geographical components, biological and ecological components, land use and socio-cultural components and economic and operational components.

For the final interpretation and representation 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*

INTRODUCTION

Currently the procedure of environmental impact assessment can be performed by more than fifty methods and techniques. These methods and techniques are derived from numerous and varied scientific disciplines dealing in both with human impact on the environmental components and with the socio-economic aspects of management, planning, legislation, etc. Among the most used methods in environmental impact assessment are checklists and matrix methods (Muntean, 2005).The simple checklists are based on a priori judgments issued and achieve a hierarchical list of factors to be taken into account in the assessment. They allow the identification, organization, assessment and character of impacts.

Checklists are important because they allow ordering of ideas, facilitate the collection of data and information and help to better locate the source of impact.

Matrices can be used to identify, systematically study, visualize and evaluate the majority of environmental impacts. A simple matrix is a combination of two checklists; one describes potential impacts on existing activity/project (distributed on columns) and the other includes the environmental and socio-economic factors affected by these impacts (distributed on lines). 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 best adaptation of Leopold’s matrix is 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 judgements 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 judgments made (Kuitunen et al., 2008). In the original RIAM method five evaluation criteria are used, namely impact importance (A1), magnitude (A2), permanence (B1), reversibility (B2) and cumulativity (B3) (Pastakia, 1998).

METHODOLOGY AND RESEARCH AREA

In the current study we analyzed 37 specific components classified into 4 categories: physical and geographical components (PGC), biological and ecological components (BEC), sociological, cultural and land use components (SCC), economical and operational components (EOC).

In terms of choosing the components analyzed we took in account the area’s specificity, thus removing many components which related to very small and specific areas with little relevance. We also eliminated items for which data collection required time/resources that were beyond the current project (sedimentation, compaction, grass, crops, hunting and fishing, animal husbandry, etc.). By eliminating these components we tried to keep the matrix in a simpler format while still analyzing enough information to properly quantify the environmental impact in the studied area (see table 1). On the other hand the rest of the data used in this study is compiled from different bibliographical sources, local and regional authority reports and author’s previous studies (undergraduate work, master's thesis, scientific articles developed over the years).

Table 1. *Analyzed categories and components*

Physical and Geographical Components	Biological and Ecological Components	Sociological, Cultural and Land Use Components	Economical and Operational Components
Geological Substrate/ Mineral Resources	Trees	Land Use	Human Health and Safety
Soil	Bushes	Open Spaces and Wilderness	Unemployment Rate
Terrain Morphology	Aquatic Plants	Forests	Tourism
Water Quality	Birds	Pastures	Population Density
Surface Water	Terrestrial Animals and Reptiles	Farmland	Waste Storage
Air Quality	Fish and Crustaceans	Parks and Reservations	Transport Networks
Air Temperature	Ecological Corridors	Rare and Unique Species and Ecosystems	Utility Networks
Floods		Historical and Archaeological Sites / Objectives	Residential Areas
Torrential/Linear Erosion		Landscape Quality	Commercial Areas
Landslides		Green Spaces	Industrial Areas

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.

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).

This method is best suited when we apply it to a dense network of points, as in our case with 49 locations distributed over 420 square km. To further refine the results of this method each point is given a positive value, representing the hierarchical position within the conurbation. The highest value is assigned to the most powerful coordination center. By implementing this extra step the method generates maps that are more detailed and closer to reality. The overlap of different types of impact maps allows quick interpretation and retrieval of information.

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 (Zotic, 2007), 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. From the administrative point of view these 49 settlements are divided into seven administrative units. The spatial and socio-economic evolution of the 49 settlements caused different environmental impacts, depending on the specific evolution and profile of each settlement.

The majority of environmental impacts are generated by industrial and economic activities, the vast majority of impacts being located in the industrial centers of Hunedoara and Călan. With more than 200 years of continued industrial activity and with increasing road and rail transit, the area experiences increasing levels of water, air and soil pollution (see table 2, 3 and 4).

Table 2. *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
Conurbation Total	49	171324	432.84	395.81

Table 3. *Hierarchy of settlements in Deva-Hunedoara conurbation (Surd, 2003)*

Rank	Settlement
County Coordination Centers	Deva
Zonal Coordination Centers	Hunedoara
Local Coordination Centers	Simeria, Călan
Large Communal Coordination Centers	Cârjiţi, Peştişu Mic
Small Communal Coordination Centers	Sântuhalm, Bârcea Mică, Mânerău, Săuleşti, Sântandrei, Bârcea Mare, Uroi, Cărpiniş, Batiz, Nădăştia de Jos, Nădăştia de Sus, Sâncrai, Valea Sângeorgiului, Călanu Mic, Strei, Tâmpa, Valea Nandrului
Village Coordination Centers	Archia, Răcăştia, Boş, Hăşdat, Simeria Veche, Streisângeorgiu Strei-Săcel, Ohaba Streiului, Grid, Sântămăria de Piatră, Petreni, Almaşu Sec, Chergeş, Cozia, Popeşti, Almaşu Mic, Josani, Nandru
Isolated Village Coordination Centers	Totia, Groş, Dumbrava, Ciulpăz, Cutin

Table 4. *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 to +100	+D	Significant Positive Changes / Impacts
+51 to +75	+C	Moderate Positive Changes / Impacts
+26 to +50	+B	Positive Changes / Impacts
+1 to +25	+A	Slightly Positive Changes / Impacts
0	N	Lack Change of the Status Quo / Not Applicable
-1 to –25	-A	Slightly Negative Changes / Impacts
-26 to –50	-B	Negative Changes / Impacts
-51 to –75	-C	Moderate Negative Changes / Impacts
-76 to -100	-D	Significant Negative Changes / Impacts
under -101	-E	Major Negative Changes / Impacts

RESULTS

Score wise general results, after the application of the RIAM method, range from -181, in Călan, to +21, in Batiz. The vast majority of results, 40 out of 49, indicate negative impacts. All of the 9 positive impact results fall in to the category +A (Slightly Positive Changes / Impacts).All of the positive results are located in rural settlements where the past and present lifestyle of inhabitants coupled with the preservation of natural resources, lack of industrial activity and with general low human density generate a well preserved natural environment. As for the other results they are distributed across 4 impact classes: 31 results in Slightly Negative Changes / Impacts category, 6 results in Negative Changes / Impacts category, 1 result in Moderate Negative Changes / Impacts category and 2 results in Major Negative Changes / Impacts category. The majority of the negative results are generated by multiple factors, both internal and external to the analyzed location. Even if the majority of the results are recorded in –A category we cannot ignore the cumulative perspective and must be aware of the potential future growth of impact associated with the predicted socio-economic development of the conurbation.

Referring to the results in Physical and Geographical Components category we can identify 16 locations with a positive impact with scores ranging from +1 to +10 (Josani). In the negative impact category we obtained 33 results with scores ranging from -1 to -65 (Hunedoara). The very low score given to Hunedoara is a consequence of intense air, water and soil pollution of the area. Again we observe a clustering of the moderate negative impacts in the urban centers of Deva, Hunedoara and Călan were the impact of factors such as air quality, water quality and soil is significant. In general, many of the negative impacts from the –A class suggest one of the fallowing two scenarios: proximity to a stronger source of impact (with cumulative and dispersive effect) or a slightly negative impact in one of the analyzed components (air, water, soil, etc.). As for the limited number of positive impacts recorded they are a consequence of a general low human density and distance from major impact sources.

A similar trend is recorded in the Biological and Ecological Components category were 17 results indicated positive impacts from +3 to +43 (Deva), 26 results indicated negative impacts from – 1 to -15 (Călan) while 6 results were 0 (no change). The positive impact reported in Deva is a consequence of the many protected areas that have the role of ecological corridors (Dealul Cetăţii, Dealul Colţ, Pădurea Bejan). The lowest score is recorded in Călan and is a consequence of the low quality, quantity and diversity of biological components. Historic industrial pollution of the area also had an effect on the biological components drastically reducing the number of biological species that thrive in the area. The high number of result ranging from -3 to +3 (26) showcases the remarkable stability and resilience of the analyzed components. Opposite to other classes analyzed these results do not present any particular spatial clustering (figure 1).

In the Sociological, Cultural and Land Use Components category the recorded trend in results is reversed, 37 out of 49 locations have a positive score with the highest being +51 (Deva). Similar results are recorded in Hunedoara (+25) and Simeria (+33). Again, the lowest recorded result is in Călan (-28) and is a combined consequence of imbalanced Land Use, lack of forests, low overall Landscape Quality and lack of Historical and Archaeological Sites / Objectives and lack of Rare and Unique Species and Ecosystems. At the other end of the result scale in Deva the high score reflects the presence of many Unique Species and Ecosystems, Archaeological Sites and also a higher Landscape Quality. All of the +A class (+1 - +25) results (34) are located in rural areas and can be regarded as the result of a balanced land use, preservation of forests and pastures and the presence of vast open spaces.

As expected in the last category, Economical and Operational Components, the vast majority of results are in the negative scale (47 out of 49). This is due to intense urbanization and industrialization of the area which causes 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 cause of the high negative impact scores. Regarding the spatial distribution of these impacts we identified only one major clustering pattern which fallows the major transport corridors and incorporates the 4 urban centers and the villages located in the corridor (results from -16 to -86).

A much clear and suggestive analysis of the distribution of the total impact within the conurbation is shown after applying the IDWM. Thus 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 part of the territory on the Zlaşti, Peştişului, Nandrului and Cristurului valleys and in the eastern part on the Săuleşti – Simeria – Băcia – Petreni – Batiz alignment. We also observe several isolated locations with positive results that tend to form a cluster in the southern part of the conurbation: Nădăştia de Jos – Nădăştia de Sus – Strei – Ohaba Streiului – Grid (table 5).

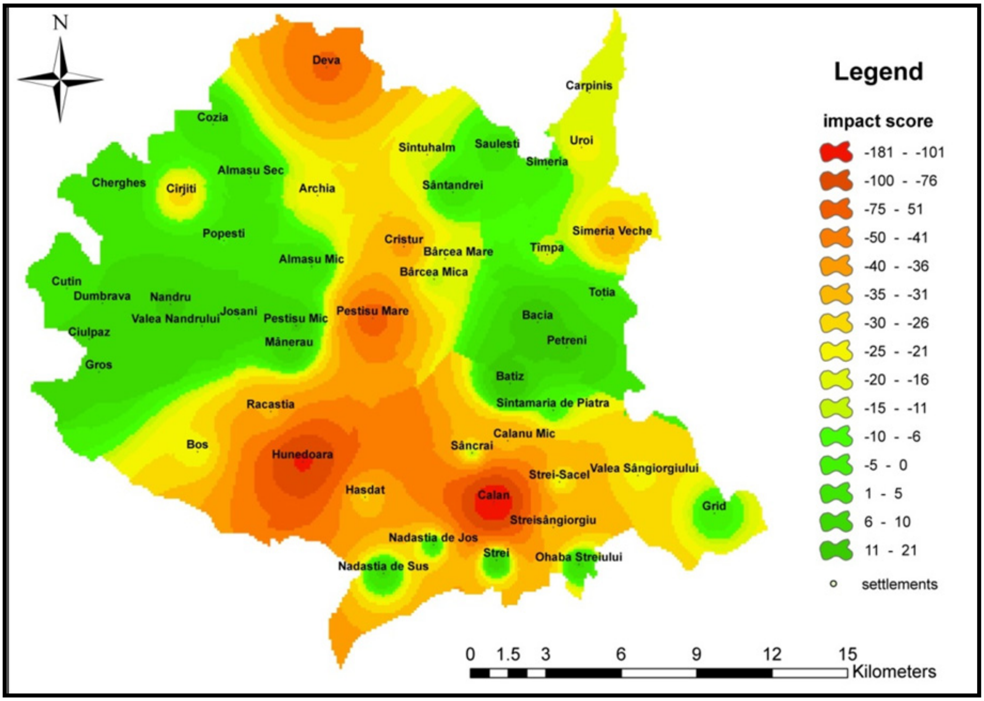

Fig. 1. *Environmental impact in Deva-Hunedoara conurbation – IDWM – preliminary results*

Table 5. *RIAM method - preliminary results*

Name	Physical and Geo-graphical	Biological and Ecological	Sociological, Cultural and Land Use	Economical and Operational	Total Impact Score	Total Impact Class
Deva	-59	+43	+51	-69	-34	-B
Hunedoara	-65	-4	+25	-57	-101	-E
Simeria	-17	+35	+33	-56	-5	-A
Călan	-52	-15	-28	-86	-181	-E
Almaşul Mic	+6	-4	+7	-12	-3	-A
Almaşul Sec	-13	+13	+9	-14	-5	-A
Archia	-9	-6	-3	-3	-21	-A
Băcia	-3	+4	+13	-3	+11	+A
Bârcea Mare	-5	+3	+12	-23	-13	-A
Bârcea Mică	-5	+3	+9	-19	-12	-A
Batiz	+3	+10	+19	-11	+21	+A
Boş	-12	+6	-4	-10	-20	-A
Călanu Mic	-3	-6	-1	-16	-26	-B
Cârjiţi	-3	-9	-6	+2	-16	-A
Cărpiniş	-18	+6	+6	-8	-14	-A
Chergheş	-5	+3	+4	-8	-6	-A

Ciulpăz	-7	-1	+10	-3	-1	-A
Cozia	-7	+3	+12	-12	-4	-A
Cristur	-9	0	-3	-11	-23	-A
Cutin	-10	-1	+10	-10	-11	-A
Dumbrava	-3	-1	+6	-6	-4	-A
Grid	-4	-3	+3	-7	-11	-A
Groş	-1	+3	+3	-6	-1	-A
Hăşdat	-18	+3	-2	-12	-29	-B
Josani	+10	-3	+9	-9	+7	+A
Mânerău	+3	0	-2	+2	+3	+A
Nădăştia de Jos	+9	-5	-4	-6	-6	-A
Nădăştia Sus	+6	-5	+4	-6	-1	-A
Nandru	+6	-2	+14	-10	+12	+A
Ohaba Streiului	+3	-3	+6	-8	-2	-A
Peştişu Mare	-17	0	-11	-31	-59	-C
Peştişu Mic	+9	-3	+9	-9	+6	+A
Petreni	+4	+9	+7	-8	+12	+A
Popeşti	-3	-3	+2	-6	-10	-A
Răcăştia	-16	+3	-9	-17	-39	-B
Sâncrai	-4	-3	+4	-9	-12	-A
Sântămăria de Piatră	-3	-8	+3	-5	-13	-A
Sântandrei	+2	0	+6	-12	-4	-A
Sântuhalm	+3	+3	+7	-26	-13	-A
Săuleşti	+1	+3	+8	-17	-5	-A
Simeria Veche	-13	-6	+6	-26	-39	-B
Strei	+2	-6	+11	-5	+5	+A
Strei-Săcel	-14	-3	+3	-6	-20	-A
Streisângeorgiu	-9	-6	-3	-10	-31	-B
Tâmpa	+3	0	+6	-22	-13	-A
Totia	-9	-8	+6	-3	-14	-A
Uroi	-15	0	+9	-10	-16	-A
Valea Nandrului	+7	-6	+12	-9	+4	+A
Valea Sângeorgiului	-3	-8	+3	-8	-16	-A

CONCLUSIONS

Conducting Environmental Impact Assessment studies with RIAM and IDWM combines flexibility with a powerful spatial interpolation method allowing the development of multiple impact scenarios with limited resources.

The flexibility offered by RIAM in choosing the components that are analyzed allows this method to be successfully applied to multiple areas of study. In our case this method provided satisfactory results combining the author's knowledge of the area with data gathered from local and regional authorities. Displaying the matrix in an electronic form (excel) offers multiple possibilities for extracting and interpolation and alteration of data, in order to create and validate impact scenarios.

The graphic representation done with IDWM further enhances the results obtained with RIAM by adding weight to the impact point. Maps created with this method are suggestive and easily understandable by both professionals and common folk alike.

The limitations of the method are well known and discussed and refer to the subjectivity of the person applying the method. Proposals to counter this fault include mitigation of results and interdisciplinary teams of local experts.

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