ANALYSIS OF RESTRICTIVE ENVIRONMENTS IN THE SOUTH-WEST OLTENIA DEVELOPMENT REGION

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Abstract. Restrictive environments can be defined as an area within a territorial system where development is constrained either by natural factors or anthropogenic factors. This paper aims to identify restrictive environments through multi-criteria analysis of Romania's South West Oltenia development region, known for its issues regarding open-pit mining, desertification or flood risk. In order to achieve this, I proposed a typology of restrictive environments, based on an extensive literature review of natural and anthropogenic factors that can limit development. For each of the ten environmental restrictiveness types identified, several criteria were proposed, which were then weighted as a result of a questionnaire addressed to experts in the field of territorial planning. Based on the questionnaire results, an index of environmental restrictiveness is computed at LAU 2 level for the entire South-West Oltenia development region. The territorialized index highlights the environmental restrictiveness of areas susceptible to flood risk (e.g. along the Jiu valley), but also the problems faced by mining areas (Motru-Rovinari) or isolated mountain areas. The computed index represents a first step towards the definition of potential inter-communal cooperation structures, that could become the object of territorial planning instruments aimed at mitigating restrictive environments.

Key words: environmental restrictiveness index, environmental degradation, natural hazards, territorial planning, inter-communal structures.

1. Introduction

The territory, defined as a limited geographical space, with somewhat homogenous characteristics (Painter, 2010), is actually characterized by geographical discontinuities (Faludi, 2004) commonly referred to in literature as territorial disparities. Indicators are used to describe the reality of a territory (Prezioso, 1995), with socio-economic indicators being the main tool used to measure territorial disparities (Medeiros, 2012).

Territorial cohesion policies represent an attempt to reduce disparities at different territorial levels (Niebuhr and Stiller, 2003). At EU level, it emphasizes the connection between economic efficiency, social cohesion and environmental balance, placing sustainable development at the heart of European policy (CEC, 2008). Nevertheless, due to the indicators usually chosen to assess these disparities, environmental factors are often left out from territorial cohesion policies. Some authors point out that neglecting environmental aspects when dealing with territorial disparities can aggravate environmental degradation issues in disadvantaged areas (Salvati and Zitti, 2007), thus causing new social and economic problems. Consequently, environmental cohesion (Saghin, 2015) should be considered another pillar of territorial cohesion, alongside economic and social cohesion.

1.1. Background

In this context, the concept of restrictive environments, referring to areas in a territorial system where development is constrained by natural or anthropogenic factors (Cocheci, 2016), can sum up the environmental factors that need to be taken into consideration when assessing territorial disparities for planning purposes.

As a result, three sources can be identified for defining restrictive environments (Cocheci, 2016):

- Natural restrictiveness, based on a deterministic perception of geography stating that social and economic development is based on geographical factors, with constraints determined by the characteristics of the natural sub-system (e.g. areas affected by natural hazards).
- Anthropogenic restrictiveness, based on a possibilistic perception of geography stating that the society can adapt to the limits and opportunities offered by the natural environment, with constraints determined by the impact of anthropogenic activities on these natural elements.
- Legislative restrictiveness, where constraints on development are imposed by norms meant to protect natural elements from anthropogenic impact (natural protected areas), or by the strict regulation of already identified restrictive environments (e.g.: building interdictions in flood-prone areas).

The restrictive environment concept can be regarded as a complement to the more socio-economic oriented notion of disadvantaged areas (Ianoş, 2001, Serban and Ianoş, 2012). Disadvantaged areas are mostly described through indicators referring to quality of life, potential of development and economical characteristics, also taking into account the areas' historical evolution and accessibility (Ianoş *et al.*, 2010). Based on an analysis of territorial disparities, the identification of disadvantaged areas is linked to the description of development discontinuities – often related to rural poverty caused by massive lay-offs in the post-communist era affecting the commuting workforce (Turnock, 2005) – and the analysis of development processes at different scales (Ianoş *et al.*, 2009). Another interesting relation is the one between restrictive environments and spatial isolated areas (or weak urban polarization areas – Vâlceanu, 2013), where low accessibility, defined by over 30 km distance from the nearest town, is linked with land cover changes which threaten protected environments (Petrişor, 2015a).

The choice of the study area was determined by the presence of significant environmental constraints induced by natural factors (e.g. the 2005 floods – see Armaş *et al.*, 2015), anthropogenic factors (the Motru-Rovinari mining area, considered to be the most important anthropogenic transformation in Romania – Braghină *et al.*, 2008) or both (desertification due to soil conditions and land cover changes – Stringer and Harris, 2014). Land cover changes in the South-West Oltenia region have also been analyzed by other authors, with urban sprawl, agricultural abandonment and deforestation being considered the main drivers of change (Petrişor, 2015b). As the development region is also among the poorest of the country (Cocheci, 2015), the overall aim was to consider if environmental factors also contribute to its underdevelopment. Consequently, the objective of this paper is to identify and measure environmental restrictiveness in Romania's South West region, as a first step in proposing planning instruments that can aid in the mitigation of different environmental issues.

1.2. Study area

The South-West Oltenia region contains five NUTS 3 units (counties: Mehedinți, Dolj, Gorj, Olt, Vâlcea), having a total surface of 29,212 km^2. The region thus comprises 12.25 % of Romania's national territory and 10.5 % of its population (Vîlcea, 2014). It contains 448 territorial administrative units: 40 cities (among which 11 are municipalities) and 408 communes.

The regional territory is characterized by the presence of all relief forms, from mountains to the north to the Oltenia Plain and Danube floodplain to the south (Ionuş *et al.*, 2015). The region's physical-geographical characteristics have been favourable for economic development, with South-West Oltenia being the country's most important energy producer: almost 2000 MW in hydroelectric plants (including Porțile de Fier I, the country's largest) and almost 5000 MW in thermal plants, fueled by the coal extracted in the region (Erdeli and Cucu, 2007).

The region's geographical characteristics determines the presence of a wide range of natural hazards in South-West Oltenia, ranging from geophysical hazards (earthquakes and geomorphological risks like landslides in the lower mountains and hill areas) to climate-related hazards like floods, drought and heat waves (Dumitraşcu, 2008). In spite of the system of dykes realized in the Danube floodplain, this lower sector remains vulnerable, as underlined by the floods in 2006 (Ionuş *et al.*, 2015), with the river being seen as a threat by the people living on its banks (Armaş *et al.*, 2015). The southern Oltenia plain presents significant drought-induced problems, affecting the local economy which is strongly dependent on agriculture (Vlăduț *et al.*, 2013). Forest shelter belts, combined with extensive irrigation systems, played an important part in preventing erosion during the communist era; however the land cover changes after 1990 have contributed to extensive land degradation and desertification phenomena in the south of the region (Stringer and Harris, 2014). The sandy soil, vulnerable to deflation, and degradation of the irrigation system thus contributed to drought severity in the region, especially in the Dăbuleni field, Caracal plain and the eastern part of Oltenia plain (Onțel and Moroşanu, 2014).

Over 90 % of Romania's total lignite reserves are located in the South-West Oltenia region (Dorin *et al.*, 2014). Because of its relative low caloric value, the coal has to be used in coal power plants located close to the extraction sites (Dorin *et al.*, 2014), with the latter having a negative impact on environmental quality through water thermal pollution of the Jiu river (Rosen *et al.*, 2015), air pollution (Ciobanu and Vasilescu, 2013) and landscape degradation. This adds to the environmental degradation already produced in the mining basins of the National Company of Lignite Oltenia – Rovinari, Jilț, Motru, Berbeşti and Husnicioara (Dorin *et al.*, 2014) – through massive anthropogenic interventions having significant impacts on landscape and environmental quality (Stăncălie *et al.*, 2003, Braghină *et al.*, 2009, Cocheci *et al.*, 2015). Besides the environmental issues related to coal mining and coal-based energy producing sectors, the region is also affected by environmental impacts related to oil and salt mining, with the latter being the main cause for several geomorphological hazards in the past years (Gâştescu and Roangheş-Mureanu, 2015).

The industrial past of the region's cities, affected by a restructuring economy after 1990 (Dumitraşcu *et al.*, 2014a) has led to the abandonment of numerous industrial sites, transformed into brownfields, also in Craiova, the region's most important city (Popescu and Pătrăşcoiu, 2012). This process of economic restructuring and the accessibility of different parts of the region have also influenced its entrepreneurial potential, with local poles like Strehaia facing difficulties in their economic development (Peptenatu *et al.*, 2012).

The region is rich in natural protected areas due to its varied physical-geographical conditions. Nevertheless, natural protected areas often do not have adequate management measures instituted, as illustrated by the example of the Olteț-Gorgeş natural reservation (Cirtina and Gamaneci, 2015).

The following section will highlight the typology of restrictive environments which will be then used in the definition of environmental restrictiveness criteria.

1.3. Typology of restrictive environments

Natural restrictiveness, caused by the characteristics of physical-geographical elements (geology, geomorphology, climate, hydrology, soil and biological elements), can be regarded from two viewpoints: on the one hand, the incidence of natural hazards, leading to development restrictions in certain territories and, on the other hand, the suitability of a site for different anthropogenic activities, determined by factors such as topographical stability, groundwater depth or local climate conditions (Pătroescu *et al.*, 2012).

Consequently, from a natural hazards perspective, we can underline a **geological restrictiveness** characteristic for areas vulnerable to earthquakes – especially urban areas with high population, buildings and infrastructure density (Armaş, 2012). Other geological characteristics can also be considered restrictive – for example, the presence of deep and soft sedimentary deposits can amplify seismic waves (Lang *et al.*, 2012).

As far as **geomorphological restrictiveness** is concerned, landslides represent one of the most significant geomorphological risk, representing a manifestation of slope instability (Papathoma-Köhle *et al.*, 2007) which can be aggravated by anthropogenic interventions, like building on steep slopes without taking into account the terrain's geotechnical characteristics (Armaş, 2014). Other geomorphological characteristics can also be considered restrictive for development: steep slopes, slope exposure - with northern slopes less exposed to solar radiation - and high altitudes (Bathrellos *et al.*, 2012), with the latter determining farm marginalization and land abandonment phenomena (Shao *et al.*, 2015).

Climate elements can be considered a limitative factor because of the incidence of hydro-meteorological hazards such as storms, extreme temperatures, drought or forest fires (European Environmental Agency, 2010). At global level, drought causes more economic damage than any other meteorological disaster, its social, economic and environmental impacts influencing an extended geographical territory (Tánago *et al.*, 2016). Other restrictive factors can also be mentioned. The coincidence, during spring, of high temperatures and high precipitation represent a triggering factor for floods and flash-floods (Benestad and Haugen, 2007). Moreover, in Europe, heat waves have been the hazard causing the most deaths in the last three decades (European Environmental Agency, 2010).

Considered hydrological risk phenomena (Prăvălie and Costache, 2014), floods are an indicator of **hydrological restrictiveness** in a given territory. In Europe, floods are considered to be one of the main natural disasters, causing over 100 billion € damage between 1986 - 2006 (de Moel *et al.*, 2009). Insufficient water resources can also be considered a limitative factor for economic development (Ongley and Booty, 1999).

Reduced soil fertility determines a territory's **pedological restrictiveness**, as fertile soils are an essential factor in plant growth, creating the premises for a sustainable use of land (Mäder *et al.*, 2002). Another criterion for defining pedological restrictiveness is soil erosion, considered to be one of the main environmental issues of our days (Rahman *et al.*, 2009). Soil erosion determines water pollution and lower agricultural production leading to land abandonment (Cerdan *et al.*, 2010), with extensive agriculture, road construction and resource extraction seen as catalysts of the process (Harden, 2001).

It is also possible to highlight **biological restrictiveness** of territories, especially through the presence of pathogen vectors such as insects or rodents which can have a significant negative impact in areas already affected by other natural hazards (Few, 2007). Another issue is the presence of invasive species, having a negative impact on both biological communities (Weber, 2000) and acting as pathogen agents (Hulme, 2009) affecting anthropogenic activities. Invasive terrestrial plant species, for example, affect ecosystem structure and functioning, having a critical impact on biodiversity and management policies in natural protected areas (Dumitrascu *et al.*, 2014b).

As far as anthropogenic restrictiveness is concerned, areas with significant **environmental degradation** caused by human activities have a reduced potential of attracting other economic activities, less harmful to the environment. Low air quality has a significant negative impact on human health, with particulate matter with a diameter of under 10 microns (PM 10) causing serious respiratory diseases (El-Fadel *et al.*, 2003). Low quality of water directly consumed by the population can lead to serious health problems, induced by pollutants accumulated in the organism (Moissenko *et al.*, 2010). Soil contamination caused by the use of fertilizers and insecticides, or by other pollutants originating from industrial activities has a negative effect on the quality of life, with new residential areas often developed on terrains with such contamination issues (Jie *et al.*, 2005). Historical contamination of soil can affect territories with a population of over 10,000 people, in the case of former industrial plants situated in the nearby area (Turrio-Baldassari *et al.*, 2007).

Land use changes can be also considered an important indicator of anthropogenic pressure in a territory (Popovici *et al.*, 2013), especially in open-pit mining areas characterized by the reduction of vegetation cover (Cuculici *et al.*, 2011). As land use changes can no longer be strictly related to population density growth (Li *et al.*, 2015), they tend to become a significant environmental issue in poorer areas as well. A more specific case of land use change is represented by the extension of transport infrastructure and built area, causing landscape fragmentation, determining not only ecological effects, but also a reduced quality of agricultural products or reduced attractiveness of recreational areas situated along the new infrastructure (European Environmental Agency, 2011).

Structural deficiencies can also be considered a type of anthropogenic environmental restrictiveness – they represent major dysfunctions, difficult to solve through short or medium-term policies and programmes and without a sustained logistic and financing effort. Consequently, this environmental restrictiveness will not be caused by human-nature interactions, but by certain characteristics of territorial systems determining a higher vulnerability to other environmental restrictiveness types. These structural deficiencies include demographic decline, also in the form of shrinking cities related phenomena (Rieniets, 2009), reduced human capital, with education level having an important role in a territory's economic performance (Marrocu and Paci, 2012), low accessibility contributing to the higher rurality of territories (Caschili *et al.*, 2015) and affecting the quality of life in rural areas (Brauer and Dymitrow, 2014), but also reduced administrative capacity causing reduced possibilities of accessing structural funds (Milio, 2007). Low access to technology can also be mentioned, as it affects both agricultural productivity (Jin et *al.*, 2002) and industrial performance because of high environmental costs (Porter and Van der Linde, 1995).

The last type of anthropogenic environmental restrictiveness identified is **legislative restrictiveness**. An example is the presence of natural protected areas, seen as one of the most important conservation instruments for protecting biodiversity and ecosystem services (Geldmann *et al.*, 2015). Natural protected areas can generate social conflicts in certain situations, often because of insufficient financing or the lacking interest of authorities and local communities for conservation (Iojă *et al.*, 2010). The poor informing of the local population regarding the benefits of biodiversity protection in ensuring sustainable development is also one of the main causes of regulations in natural protected areas not being respected (Ionce and Ionce, 2015). The consultation of the local population in the promotion of different management measures is thus considered to be key in the application of sustainable management policies (Kyriazopoulos *et al.*, 2015). While policies aimed at combining biodiversity conservation with poverty-reducing measures exist, there are often contradictions between the two processes which make the simultaneous attainment of both objectives impossible (Shafer, 2015). Besides the restrictions imposed by natural protected areas, other types of limitations can also be imposed through national legislation – for example, the building restrictions imposed by the General Regulation of Urban Planning (Government Decision no. 525/1996).

4. Methodology

Based on the literature review realized in the previous section, a typology of restrictive environments has been defined, with ten types of restrictive environments identified:

- Six types which describe natural environmental restrictiveness: geological, geomorphological, climatic, hydrological, pedological and biological restrictiveness.
- Four types which describe anthropogenic environmental restrictiveness: induced by environmental degradation, land use dysfunctions, structural deficiencies of the anthropogenic subsystem and legislative restrictiveness.

In order to select the most relevant criteria for defining environmental restrictiveness, a questionnaire was applied in February 2016 to experts in domains related to territorial planning. The questionnaire was chosen as a research method because it eventually enabled the ranking of the proposed criteria according to the experts' grades.

For each type of restrictive environment identified, between two and six individualization criteria were selected, based on the literature review previously realized. All in all, 39 criteria were defined, which were then assigned a value from 1 to 5 by the experts according to their assessed importance, taking into consideration the limitations imposed on local development by each criterion.

In the end, for each of the ten types of restrictive environments previously defined, I selected the criterion with the highest average score according to the experts rating. For each of the ten criteria selected in this way (which were named environmental restrictiveness factors), indicators were identified in order to quantify each type of environmental restrictiveness.

Based on the above-mentioned indicators, used to measure each of the restrictiveness factors, an environmental restrictiveness index can be defined at LAU 2 unit level. The computing method for the index was the normalization of indicator values to 100 (the value given to the maximum value obtained at LAU 2 level, for each indicator). In the end, the environmental restrictiveness index represented, for each LAU 2 unit, the normalized sum of the ten indicators. As a result, the index can, theoretically, register values between 0 (lack of restrictive elements) and 1000 (maximum environmental restrictiveness registered for each of the ten indicators). Fig. 1 illustrates the methodology of computing the environmental restrictiveness index at LAU 2 unit level for the entire South-West Oltenia region.

The open-source software QGIS Desktop 2.8.2 was used for spatializing the indicators and realizing the necessary vector processing operations in order to obtain certain indicators related to surface and density, for all 448 LAU 2 units in the region.

5. Results and discussions

The questionnaire was completed by 26 experts – almost half were urban planners (11 – approx. 42 %), followed by specialists in human geography (8), environmental sciences (4), architecture

(2) and engineering (1). Most of the respondents had their main work place in a university (18 – approx. 70 %), followed by experts working in the private sector (5), in local public administration (2) and central public administration (1). Most of them had at least 10 years of experience in the domain (10), followed by those with 2-5 years of experience (8), 5-10 years (6) and under 2 years (2). Almost two thirds of the respondents (17) declared that they had worked, in the past, in projects or research studies regarding territories that could be labelled as restrictive environments.

Table 1 illustrates the scores obtained after applying the questionnaire, while Table 2 presents the indicators used for measuring environmental restrictiveness in Romania's South-West Oltenia region.

I have chosen to represent geological restrictiveness, defined by high seismicity, through the peak values of the terrain acceleration, based on the seismic area zoning maps from the P100-1/2013 Normative regarding the Code of Seismic Design. Consequently, the eastern area of the region, including cities such as Râmnicu Vâlcea, Brezoi, Călimăneşti or Potcoava, is the most vulnerable one, with a peak value of the terrain acceleration of over 0.25 m/s2.

As far as landslide susceptibility is concerned, due to the quality of data differences between the Plans of Risk Analysis and Cover (PAAR) approved by the County councils, I have chosen to resume myself to presence/absence data. As the county of Mehedinți did not have an approved PAAR, the data was instead taken from the National Territorial Plan Section V – Areas of Natural Risk (Law no. 575/2001). The northern part of the region (Vâlcea, Gorj and Mehedinți counties) is far more prone to landslide hazard than the southern part, due to the region's topography – for example, over 75 % of the towns and communes in Gorj county have been affected by landslides in the last years.

For the floods and flash-floods restrictiveness factor, I also opted for presence/absence data, based on the publicly available data regarding areas of significant potential flood risk (ASPFR) provided by the European Environmental Agency (European Environmental Agency, 2014a).

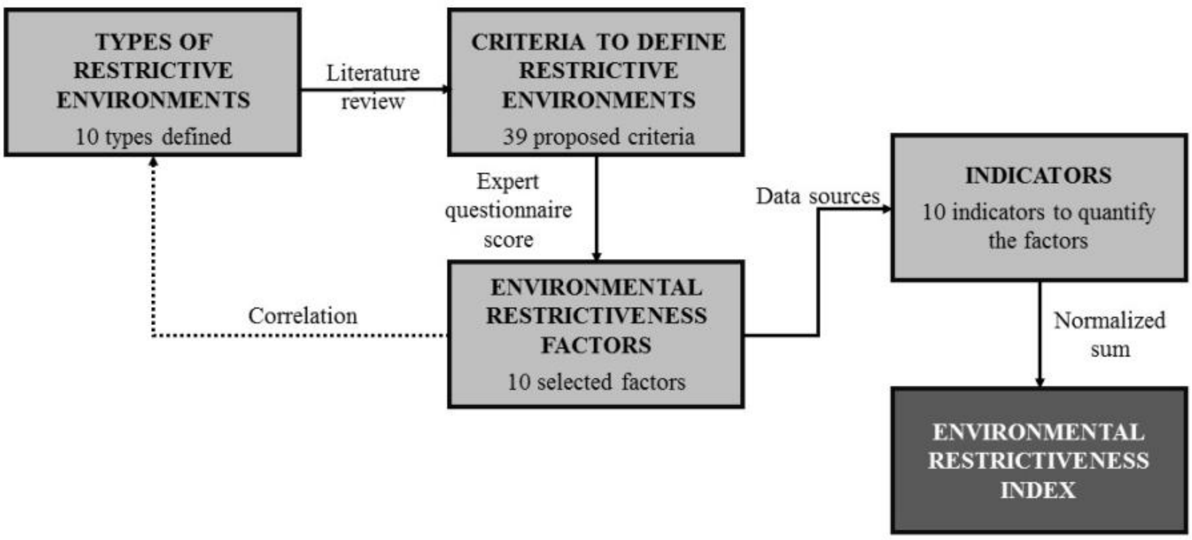

Fig. 1. Methodology of defining an environmental restrictiveness index

Table 1. Questionnaire scores for each considered criteria

Restrictiveness type	Restrictiveness criteria	Score
Geological	**High seismicity**	**4.15**
	Difficult rocks for building foundations	3.54
Geomorphological	**High susceptibility to landslides**	**4.50**
	Other slope processes	4.15
	High altitudes (over 1200 m)	2.58
	Relief fragmentation	3.12
	Northern exposure of slopes	2.54
	Steep slopes	3.15
Climatic	**Drought**	**3.00**
	Extreme climatic phenomena (storms and winter storms)	2.96
	Extreme positive temperatures (heat waves)	2.73
	Extreme negative temperatures	2.85
	High quantity of precipitations between November and March	2.50
Hydrological	**High incidence of floods and flash-floods**	**4.12**
	Insufficient water resources	3.88
	Low groundwater depth (under 2 m)	3.04
Pedological	**High soil erosion**	**3.19**
	Reduced soil fertility	2.81
Biological	Presence of valuable species and habitats	3.58
	Spread of biological vectors causing epidemics	**3.85**
	Presence of invasive species	2.73
Environmental degradation	Low air quality	3.58
	Reduced quality of surface waters	3.42
	Reduced quality of groundwater	3.42
	Contaminated soils (pollutants from industrial activity)	**3.96**
	Excessive use of insecticides and pesticides (agriculture)	3.58
	Loss of biodiversity	3.19
Land use dysfunctions	**Excessive relief artificialization: open-pit mining, tailing ponds and dumps**	**4.19**
	Important land use changes: deforestation, extension of built surface	3.69
	Landscape fragmentation caused by infrastructure (high-ways, railways)	3.00
Structural deficiencies	Demographic deficit (aging population and population decline)	3.73
	Low level of population culture (education level, entrepreneurial capacity)	3.69
	Low physical accessibility	**4.15**
	Reduced access to agricultural and industrial technology	3.69
	Reduced administrative capacity	3.81
Legislative	**Presence of natural protected areas**	**4.00**
	Protection perimeters – major infrastructure, military areas	3.69
	Sanitary protection areas	3.50
	Other building interdictions (determined by natural risk susceptibility, protection of surface waters, etc.)	3.58

Most of the areas prone to flood risks are situated along the Danube, Jiu, Motru and Olteț valleys, with the river Olt considered to be safe from flood risk because of the hydrological arrangements along its valley (Fig. 2).

Table 2. Indicators used for measuring the selected environmental restrictiveness factors

Environmental restrictiveness factor	Indicator (LAU 2 level)	Data source
High seismicity	Value of terrain acceleration of earthquakes of an average recovery period of 100 years	Normative P100-1/2013
Landslides	Presence / absence	National Territorial Plan Section V
Drought	Percent of LAU 2 unit surface with mean susceptibility to desertification	EEA (2008)
Floods and flash-floods	Presence / absence	ASPFR – EEA (2014)
High soil erosion	Suprafață terenuri degradate și neproductive (ha)	INSSE
Spread of biological vectors causing epidemics	Percent of wetlands from the total LAU 2 unit surface	CLC 2006 – code 411
Contaminated soils	Number of contaminated sites	Environmental Protection Agency (APM) data
Excessive relief artificialization	Percent of extraction areas and dump sites from total LAU 2 unit surface	CLC 2006 – code 131 and 132
Low physical accessibility	Composed accessibility index (based on road and railway density in each LAU 2 unit)	Processed Open Street Map data
Presence of natural protected areas	Percent SCI (Natura 2000 – Site of Community Importance) surface from LAU 2 unit surface.	Ministry of Environment (MMAP) data

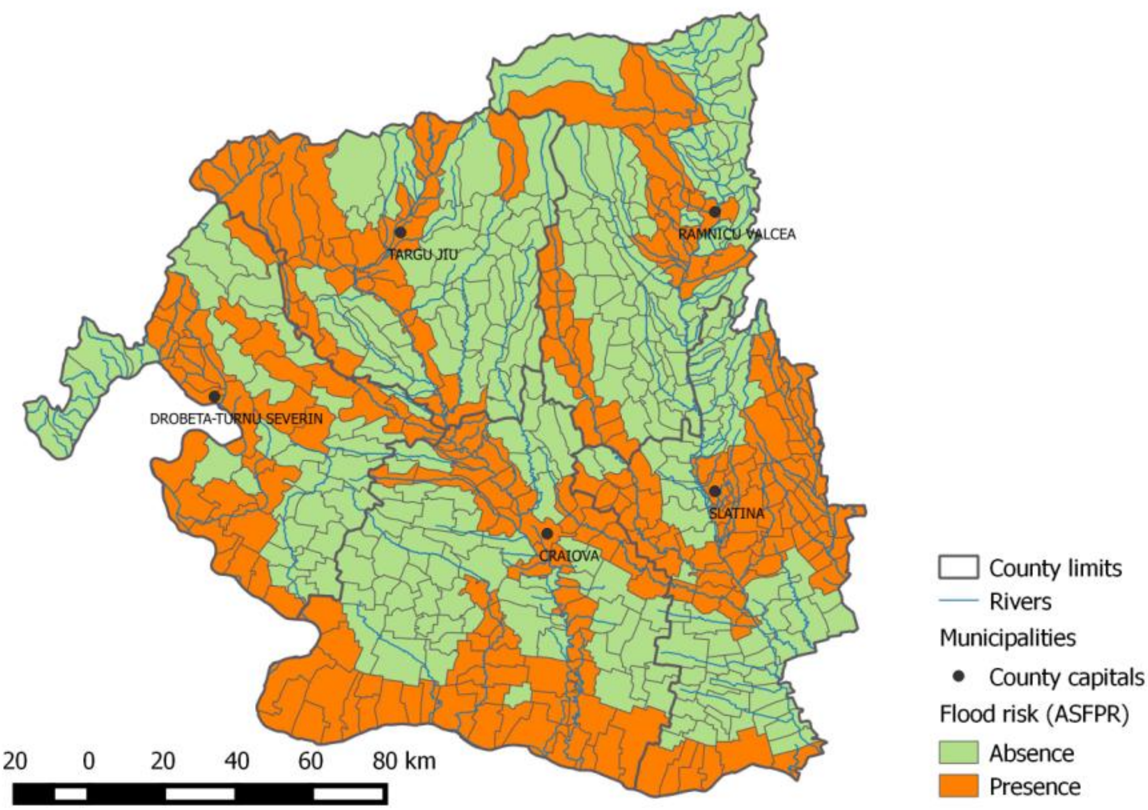

Fig. 2. Hydrological restrictiveness – areas of potential significant flood risk (APSFR)

Regarding climate restrictiveness, drought was quantified using the desertification susceptibility index, also based on a climatic aridity index. The dataset was downloaded from the European Environmental Agency site (European Environmental Agency, 2009). It was afterwards processed in order to compute, for each LAU 2 unit, the percent of surface considered to have at least a medium susceptibility to desertification. Consequently, the LAU 2 units with over 50 % of their surface with medium or higher susceptibility to desertification were grouped in the central part of Mehedinți county (south of Drobeta Turnu Severin) and Dolj county, as well as in the eastern part of Olt county (east of the Olt river).

The pedological restrictiveness factor – soil erosion – was quantified at LAU 2 unit level using the total degraded terrain surface, the data source being the TEMPO-online database of the National Institute of Statistics (2013 data). The most affected LAU 2 units (over 500 hectares of degraded terrain) were situated in the lignite extraction areas in the Motru-Rovinari basin, but also in the vicinity of Baia de Arama and Tismana towns. The maximum values (over 1900 hectares) were registered in the communes of Cîlnic and Mătăsari, in the Gorj county (Fig. 3).

In order to quantify the vulnerability to pathogen agents causing epidemics, we considered, for each LAU 2 unit, the percent of wetland surfaces from the total surface, computed using the Corine Land Cover 2006 dataset (European Environmental Agency, 2014b). The highest registered values (over 10 %) were located along the Danube valley, in Dolj county, with the commune of Cârna having over 26 % of its surface occupied by wetlands.

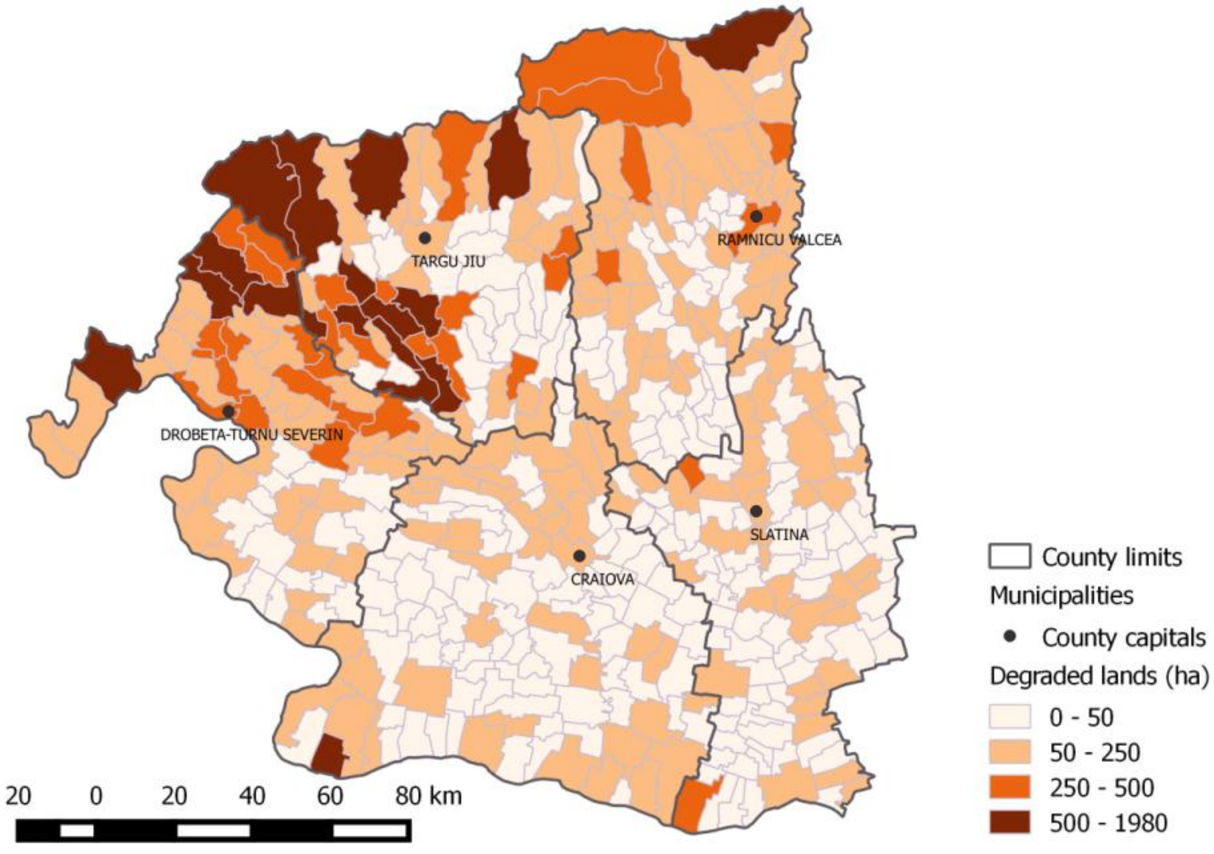

Fig. 3. Pedological restrictiveness – degraded land surface

Regarding anthropogenic restrictiveness determined by environmental degradation, the *contaminated sites* restrictiveness factor was measured using the data regarding the number of contaminated sites, obtained from the Environmental Protection Agencies at county level. Most of the contaminated sites are related to oil extraction activities, with the highest number of contaminated sites located in the commune of Cungrea in Olt county.

The excessive relief artificialization, caused by the presence of tailing dumps, tailing ponds or open-pit mining can be also assessed using Corine Land Cover 2006 data (European Environmental Agency, 2014b). By calculating the percent of each LAU 2 unit surface occupied by extraction areas or dump sites (CLC codes 131 and 132), the problems already associated with the lignite mining areas of Motru-Rovinari and Alunu-Berbeşti were again highlighted, with the maximum value registered in the city of Rovinari (over 63 %).

As far as structural deficiencies are concerned, low physical accessibility was measured using an accessibility index, based on a simple ranking of LAU 2 units according to their national and county road density, on the one hand, and railway density, on the other hand – with the lowest ranked LAU 2 unit (the city of Craiova, value 1) being the most accessible town or commune in the region. Consequently, the less accessible regions were considered to be in the north-west of Gorj county (around the town of Tismana), north of Vâlcea county, south of Dolj and Olt county (Bechet – Dăbuleni – Corabia area) and the center-east of Olt county (Fig. 4).

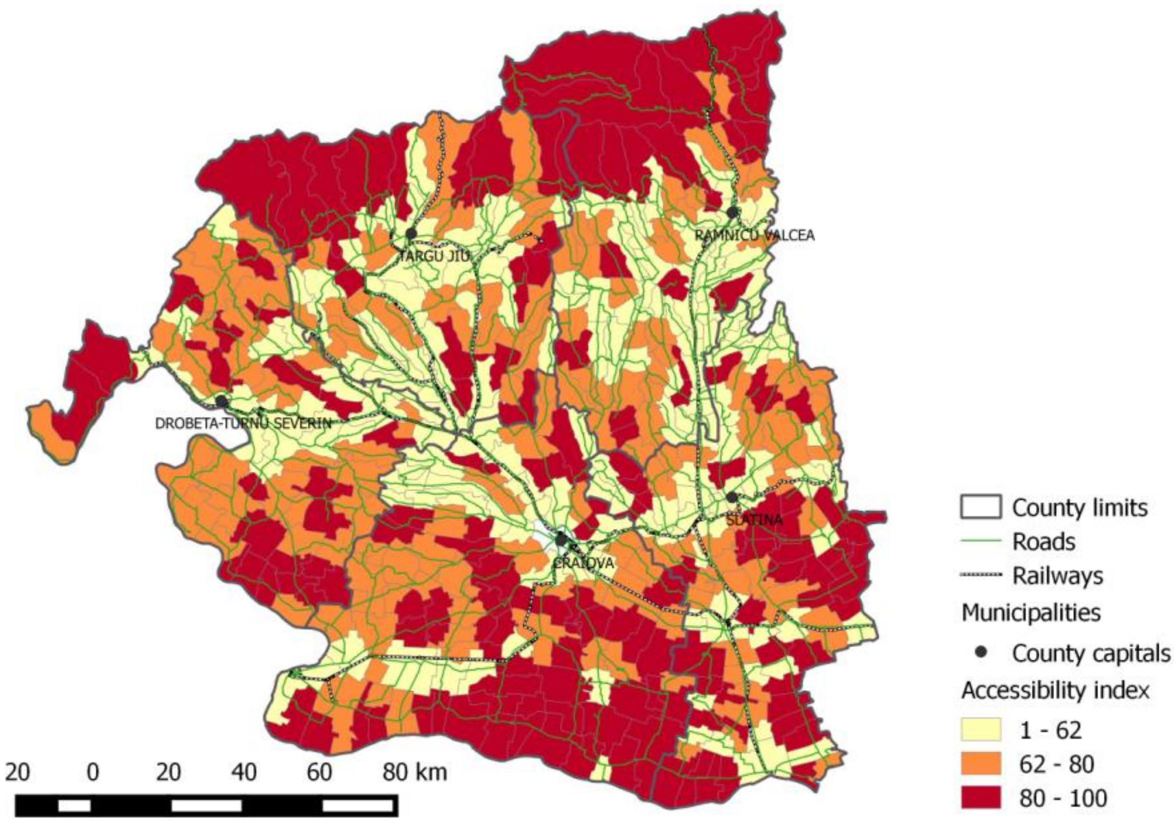

Fig. 4. Structural deficiencies – accessibility (road and railway composite index, higher values mean lower accessibility)

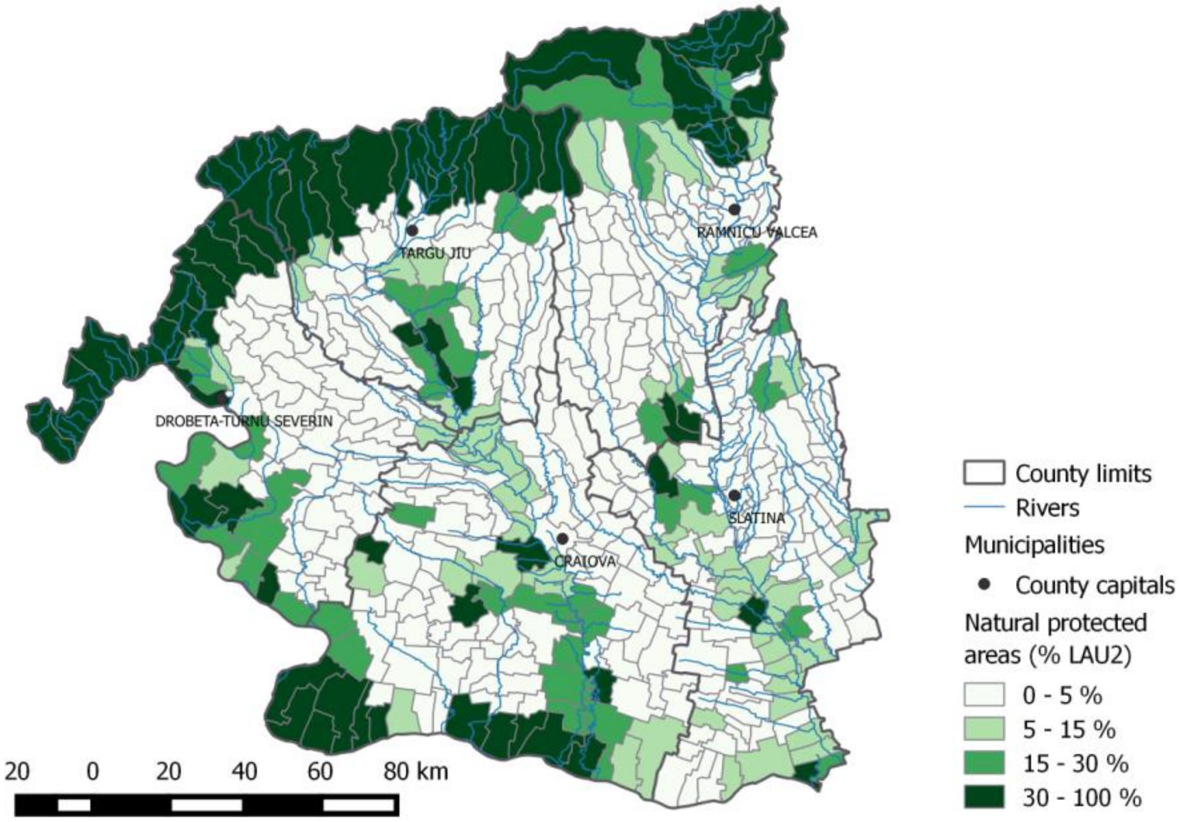

Fig. 5. Legislative restrictiveness – percent of surface occupied by Natura 2000 SCI sites

Legislative restrictiveness was measured by using the *natural protected areas* criterion, where the surface of Natura 2000 SCI sites (selected because they are the natural protected area with the widest covering of Romania's territory – see Iojă *et al.*, 2010) was computed and then compared to the total surface of each LAU 2 unit. The spatial dataset used for computing this indicator was downloaded from the Romania's Ministry of Environment website. The results showed a concentration of LAU 2 units with over 30 % surface occupied by SCI sites in the north, mountainous area of the region, as well as in the south, along the Danube valley. Some communes, like Obârşia-Cloşani and Podeni, in Mehedinți county, have their entire territory within a Natura 2000 SCI site (Fig. 5).

In the end, the computed restrictiveness index for all LAU 2 units in Romania's South-West Oltenia region registered values ranging from 76 (Bolboşi commune, Gorj county) and 500 (town of Tismana, also in Gorj county). The computed values for the index were then grouped in sextiles, with an area being defined as a restrictive environment if two conditions were simultaneously met: at least three contiguous LAU 2 units in the upper sextile, as well as at least five LAU 2 units in the upper third of the value range (Fig. 6).

Consequently, nine intercommunal areas ranging from five to 27 LAU 2 units were defined as restrictive environments in the South-West Oltenia region (Fig. 7, Table 3). All in all, 108 LAU 2 units (24 % of LAU 2 units in the region) where included in areas defined as restrictive environments. Of these, only 10 were towns (25 % of the region's towns).

Table 3. Description of areas individualized as restrictive environments

No.	Name (number of LAU 2 units)	County: LAU 2 units	Comments
1	Tismana - Baia de Aramă (7)	Gorj (5): Tismana (town), Godineşti, Runcu, Padeş, Pestişani. Mehedinţi (2): Baia de Aramă (town), Ponoarele	Landslide and flood risk. Natural protected areas and low accessibility (Padeş, Tismana).
2	Novaci (5)	Gorj: Novaci (town), Crasna, Polovragi, Baia de Fier, Bengeşti-Ciocadia.	Landslide risk. Low accessibility (Crasna, Baia de Fier, Polovragi).
4	Olt North-East (27)	Olt: Scorniceşti and Potcoava (towns), Bărăşti, Poboru, Valea Mare, Şerbăneşti, Brebeni, Bălteni, Sârbii-Măgura, Priseaca. Făgeţelu, Tufeni, Izvoarele, Optaşi-Măgura, Ghimpeţeni, Spineni, Perieţi, Nicolae Titulescu, Movileni, VÎlcele, Crimpoia, Tătuleşti, Icoana, Coloneşti, Cungrea, Schitu, Văleni.	Highest earthquake risk in the region. Flood risk in almost all LAU 2 units (except Poboru and Cungrea). Relatively low accessibility (accessibility index higher than 50 in almost all LAU 2 units). Contaminated sites (Cungrea, Icoana, Poboru).
5	Segarcea – Dăbuleni – Bechet (10)	Dolj (9): Dăbuleni (town), Dobreşti, Rojişte, Teasc, Ostroveni, Bratovoieşti, Ghighera, Sadova, Valea Stanciului. Olt (1): Ianca	Landslide (Valea Stanciului) and flood risk (all). Low accessibility (accessibility index higher than 80 in almost all LAU 2 units).
6	Balş (15)	Olt (8): Balş (town), Găvăneşti, Cezieni, Baldovineşti, Morunglav, Oboga, Voineasa, Vulpeni. Dolj (6): Robăneşti, Drăgoteşti, Gherceşti, Mischii, Pieleşti, Teslui. Vâlcea (1): Laloşu	Landslide (Balş, Morunglav, Voineasa, Vulpeni, Laloşu) and flood risk (all). Susceptibility to desertification (Pieleşti, Teslui, Găvăneşti, Vulpeni). Low accessibility (Gherceşti, Teslui).
6	Jiu valley – central sector (12)	Dolj (10): Bucovăţ, Breasta, Brădeşti, Braloştiţa, Cernăteşti, Coţofenii din Faţă, Coţofenii din Dos, Greceşti, Predeşti, Scăeşti. Mehedinţi (2): Butoieşti, Stîngăceaua	Landslide (Bucovăţ, Breasta, Butoieşti, Stângăceaua, Greceşti) and flood risk (all except Bucovăţ). Low accessibility (Braloştiţa).
7	Motru-Rovinari (12)	Gorj: Motru and Rovinari (towns), Băleşti, Drăguteşti, Bîlteni, Cătunele, Cîlnic, Fărcăşeşti, Glogova, Mătăsari, Samarineşti, Urdari.	Landslide risk (all) and flood risk (all except Urdari, Mătăsari and Fărcăşeşti). Degraded land (Cîlnic, Mătăsari) and presence of tailing ponds and quarries (Rovinari, Mătăsari, Urdari). Contaminated sites (Motru, Rovinari).
8	Vânju Mare (13)	Mehedinţi: Vânju Mare (town), Şimian, Tamna, Prunişor, Livezile, Hinova, Rogova, Bicleş, Poroina Mare, Jiana, Patulele, Vlădaia, Padina.	Landslide risk (all except Jiana) and flood risk. Susceptibility to desertification (Padina, Vlădaia, Patulele, Rogova, Bicleş). Low accessibility (Padina).
9	Mehedinţi – Danube valley (7)	Mehedinţi: Burila Mare, Gruia, Gogoşu, Salcia, Pristol, Vrata, Gârla Mare	Landslide (Gruia, Pristol, Gârla Mare) and flood risk (all). Low accessibility (Gârla Mare, Vrata, Pristol).

The most LAU 2 units included in restrictive environment areas were located in Olt county (36 – 32 % of the county), followed by Dolj (25 – 22.5 %), Mehedinţi (24 LAU 2 units – 36 %) and Gorj counties (22 – 31 %). As far as the county of Vâlcea is concerned, only one LAU 2 unit was included in a restrictive environment area.

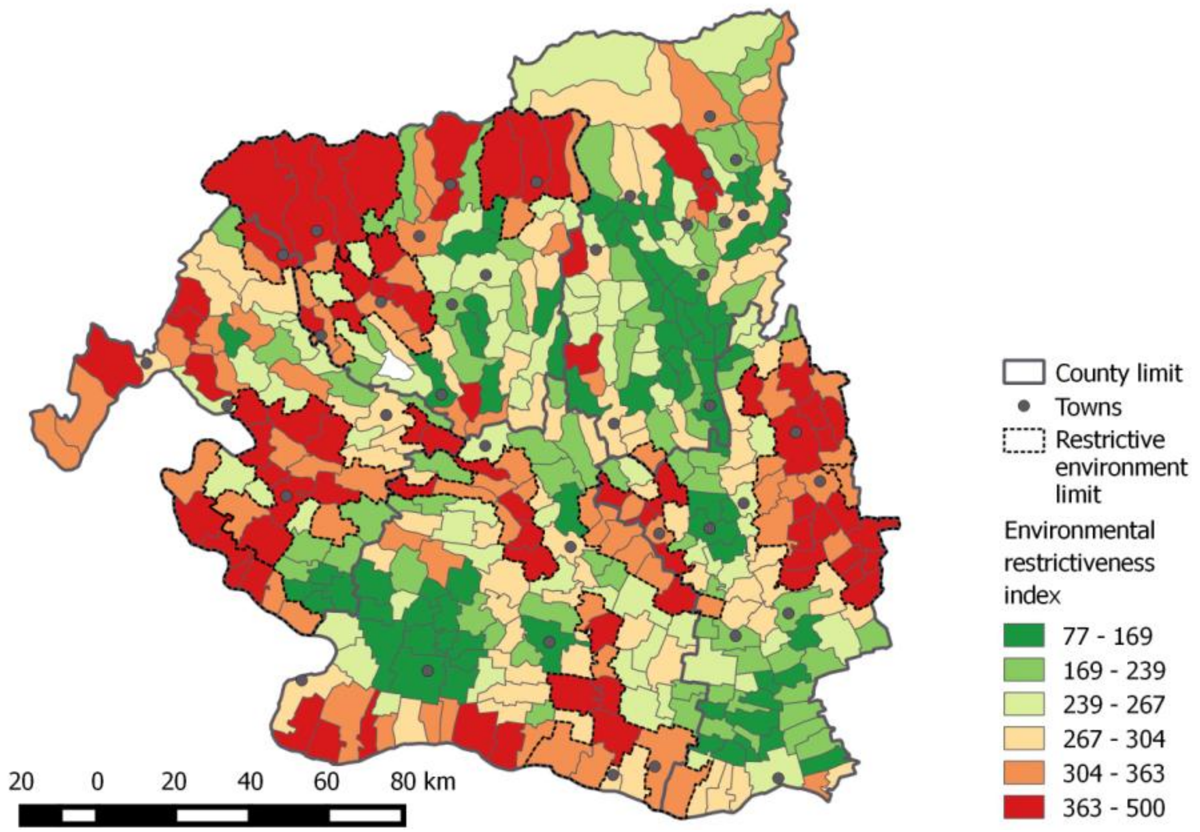

Fig. 6. Environmental restrictiveness index – computed at LAU 2 level for South-West Oltenia region

All restrictive areas defined were associated with either landslide or flood risk or both, being a characteristic element of the Balş, Jiu Valley – central sector, Mehedinți – Danube valley, Segarcea – Dăbuleni – Bechet or Tismana – Baia de Aramă areas. Low accessibility was also a problem identified in many areas, being an important issue especially for the Segarcea – Bechet- Dăbuleni, Mehedinți – Danube valley and Olt North-East areas. As far as anthropogenic restrictive factors are concerned, the Motru-Rovinari area stood out due to its problems related to the presence of tailing dumps and extraction sites, which in turn determines the high surface of degraded land observed in the area.

6. Conclusions

The proposed multicriteria analysis of restrictive environments in Romania's South West region is based on computing an environmental restrictiveness index at LAU 2 unit level. The index thus describes the towns or communes which present multiple environmental issues and becomes a tool for describing territorial disparities related to environmental factors. Eight of the ten restrictiveness factors computed (earthquake, landslide, flood and desertification risks, potential for pathogen vectors spreading illness, degraded lands, relief artificialization and contaminated sites) describe specific environmental issues with natural, anthropogenic or mixed causes. The last two restrictiveness factors computed refer to elements which, in spite of lacking a direct relationship to environmental development limits, can pose some problems as they represent either structural deficiencies of a territory (low road and railway accessibility) or can prevent certain forms of economic development due to legislative barriers (Natura 2000 SCI sites).

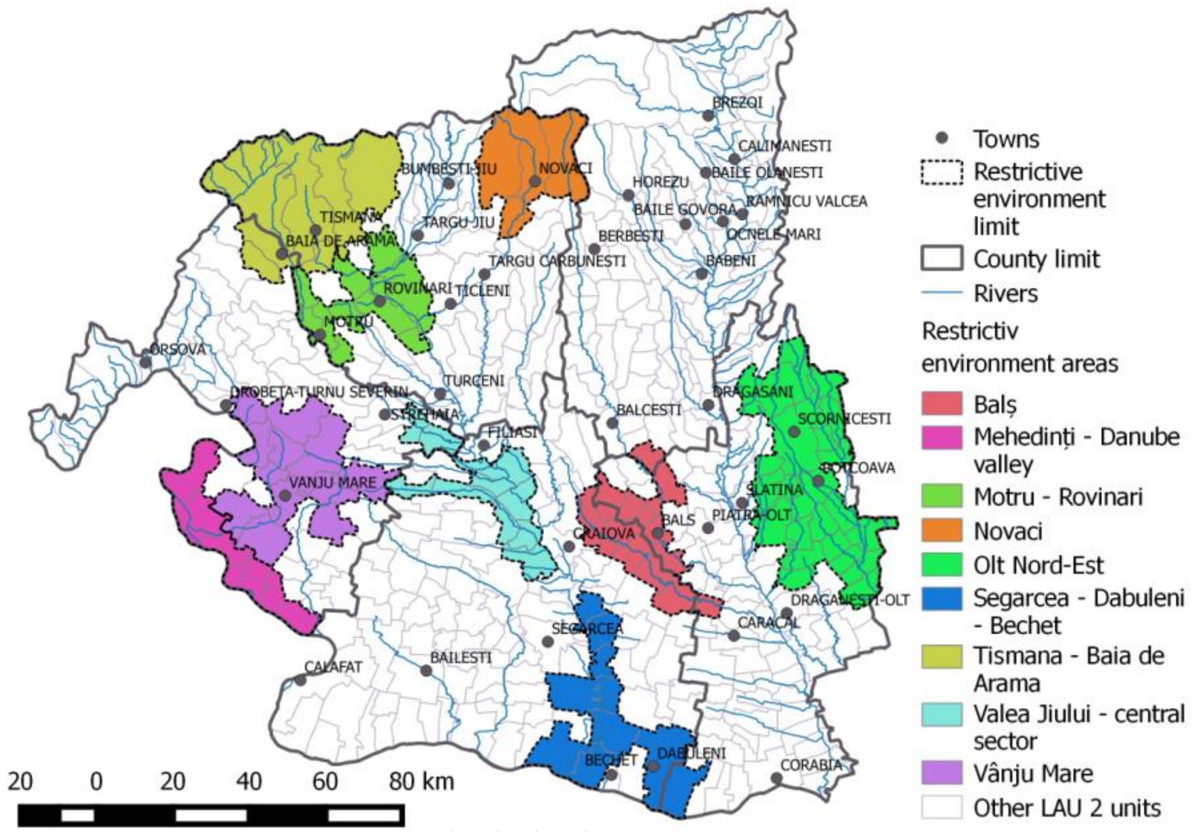

Fig. 7. Individualized restrictive environment areas

Consequently, the proposed index can be used as a tool to integrate analysis related to both natural and anthropogenic sub-systems in a territorial system. It can support the elaboration of local and sub-regional strategies, based on the definition of inter-communal areas with similar characteristics regarding the identified environmental restrictiveness factors. As in the case of territorial disparities measurements serving as a foundation for cohesion policy measures, quantifying environmental restrictiveness represents a first step in defining a regional policy for mitigating environmental issues, with spatial planning having an important role in ensuring the correlation of land use management with sectoral areas like risk management, financial and non-financial mechanisms for brownfield redevelopment or environmental rehabilitation strategies.

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