STUDIA UBB GEOGRAPHIA, LIX, 2, 2014, pp. 57-68
(RECOMMENDED CITATION)

IDENTIFYING THE INFLUENCE OF MORPHOMETRY ON THE URBAN MORPHOLOGY OF ZALĂU USING GIS

ANDREEA MARIA VÂTCA[1], SANDA ROŞCA[1]

ABSTRACT. - Identifying the Influence of Morphometry on the Urban Morphology of Zalău Using GIS. The topography is considered to be the main component lying at the basis of human activities and settlements. Its analysis can highlight the territories which are favourable or restrictive for urban expansion and city development. The present study used cartographic databases and geoinformation software to identify the present distribution of edilitary constructions on elevation and slope angle intervals, two morphometric characteristics which have the strongest influence on the urban development of Zalău Municipality. In order to highlight the geomorphological processes which influence in a negative way the city expansion, the study has identified the building distribution in each neighbourhood on landslide probability classes, these specific categories being identified using the methodology described in the Governmental Decision 447/2003. Starting from these databases, the geomorphological risk map was created. This type of analysis, which relies on the current territorial expansion of the city, offers an overall image on the future development options and enables a sustainable planning of the analysed territory.

Key-words: *morphometry, urban development, G.I.S. modelling, Zalău*

1. INTRODUCTION

The evaluation of the current situation from the Zalău Municipality illustrated in the General Urban Plan and the Zonal Urban Plan has identified a series of dysfunctions between the urban development possibilities and the related costs for making the Zalău Municipality a functional European city of the 21st century (Vâtcă, 2014).

[1] *Universitatea Babeş Bolyai, Facultatea de Geografie, 400006 Cluj Napoca, România, e-mails: schatzi2pop@yahoo.com, rosca_sanda@yahoo.com*

The aim of this study is to identify the morphology of the Zalău urban area in relationship to the morphologic potential of the territory, by analysing the geomorphological factors which determine the favourability and restrictiveness of city development. This endeavour relies on valuable databases used with the help of geoinformatic softwares previously used in similar studies (Petrea et al. 2014, Vâtcă et al. 2014, Roşca et al. 2015).

It is a well-known fact that, at national level, most cities have expanded on the territory of main valleys which developed mono-laterally, with a visible impact on the urban morphology. In many cities the underlying landforms play an important role in the urban aesthetics (Petrea, 1998).

After a first analysis, the topography was highlighted as a main factor in the development of Zalău by determining its longitudinal shape according to the morphology of the Zalău Valley, while the restrictive slope processes limited its east-west development. The morphology of the Zalău built-up area is characterised by three morpho-hydrographical convergences (Mac, 1996) which have a highly valuable potential as habitats. The maximum expansion of the built-up area was made on the terraces, especially on the 8-10 m and the 30-35 m terraces of the Zalău Valley, which had the most favourable setting. The characteristics of the valley determined the whole urban morphology. The main built-up area is built on the alluvial fan of the Meseş stream and it has a favourable setting at river and road convergences. However, its expansion is also limited by the morphology of the region. The expansion of the municipality on topography levels, each having different elevation and expansion area, has had an influence on the city aesthetics. In the built-up area of Zalău there are different morphometric levels on which the neighbourhoods have been developed: flood plain, terrace, glacis and foothill (Fig. 1).

The urban area of Zalău corresponds to the *Zalău Depression*, which evolved after the retreat of the Pannonian Sea through the river fragmentation of the seaside plain located at the boundary of the Meseş Mountains. The flow direction of the rivers was western and north-western and their erosional action is proved by the presence of the Aghireş-Panic, Crişeni-Ortelec hill saddles (Mac, 1996). The Zalău Depression has the shape of a not very extended, prolonged gulf developing on the south-north direction, with elevations between 250 m and 450 m. From a tectonic point of view, the depression consists of both permeable rocks (sand, gravel) and impermeable rocks (clay, marl) (Nicoară, 1998). The Zalău Municipality expanded on the submontain hills of Meseş which border the upper part of the Zalău Valley and developed up to the widening sector of the valley.

The morphology of the Zalău urban and suburban area is included in the category of hills, foothills and glacis. The topography underlying the Zalău Municipality belongs both to the Meseş Mountains and to the Zalău Depression, as a consequence there is a vast variety of landforms including elements of sculptural topography (or morphosculptural), structural topography (folded and monoclinal forms), petrographic topography, as well as fluvial and denudational landforms (glacis).

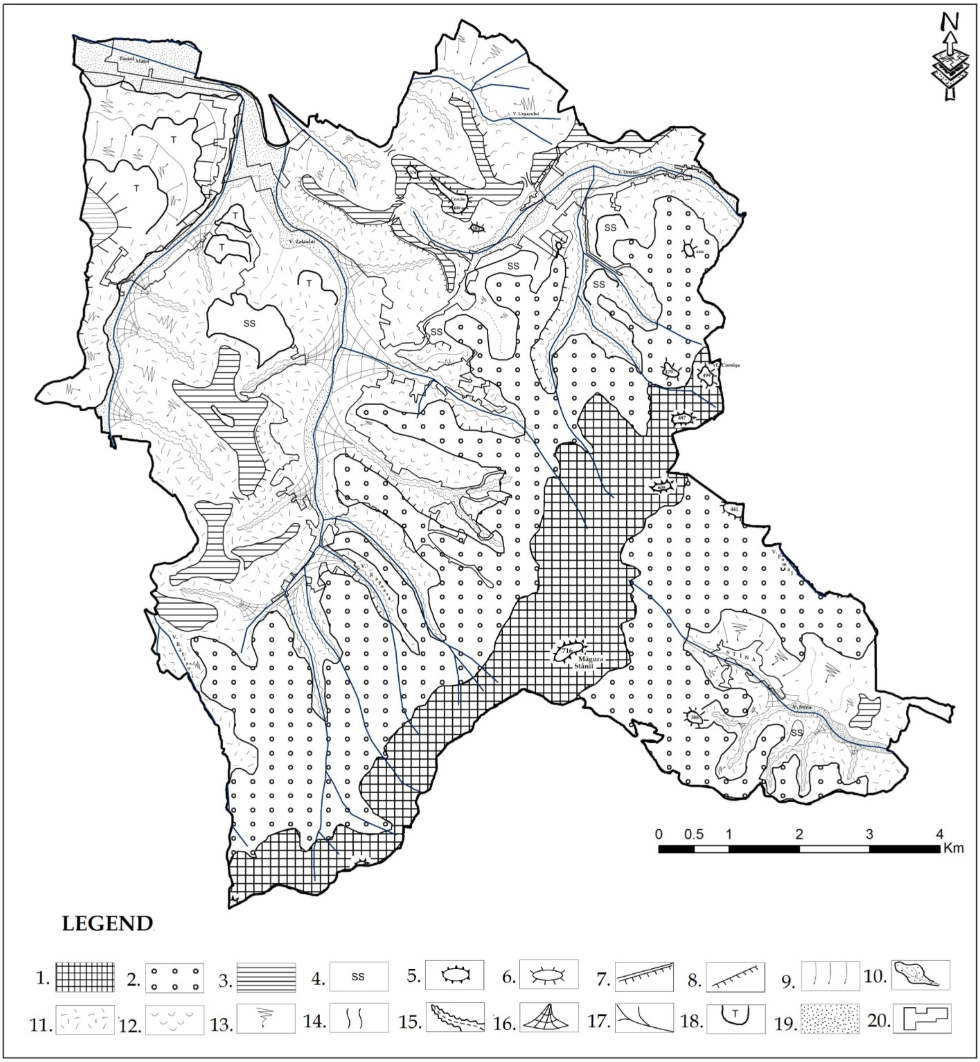

Fig. 1: Geomorphological map of the urban Zalău area (where 1 – mountain surface (600-750m), 2 – foothill surface (400-550m), 3 – erosion level (300-350 m), 4 – structural surface, 5 – structural remnant, 6 – erosion remnant, 7 – cuesta front, 8 – morphological hillslopes (scarps), 9 – connecting slopes and surfaces, 10 – erosion basin (depression), 11 –delluvial-colluvial glacis, 12 – landslides, 13 – rills, 14 – gullies, 15 – torrents, 16 – alluvial fans, 17 – permanent stream, 18 – fluvial terrace, 19 – flood plain, 20 – settlement).

2. DATABASE AND METHODOLOGY

In order to identify the influence of the main morphometric characteristics on the morphology of the Zalău urban area, a *primary cartographic dat*abase was used to extract the present spatial expansion of Zalău and it was represented by recent satellite images (Google, 2012) and topographic maps 1:25000, the latter being used for digitising contour lines. The *derived database* was created using geoinformation software, including the Digital Elevation Model (DEM) and the slope angle map. The *modelled database* included the results of applying the semi-quantitative model of determining the potential of landslide occurrence according to the methodological recommendations included in the Governmental Decision 447/2003 (Vâtca et al., 2014).

Another valuable database is represented by the geomorphological map of the Zalău urban administrative area which was created in a GIS environment starting from the analysis of the topographic map and the detailed inventory of geomophological processes in the study area, especially the main causing factors which are present in the field. Creating the inventory and the measurement of instability indices (phytogeographic, hydric, geological, anthropogenic) and of some variables of the present morphodynamic processes were necessary endeavours as there are direct concordances among tectonics, lithology, structure, morphology and morpho-climatic and morpho-hydrological contexts in which these processes occur.

3. RESULTS AND DISCUSSIONS

As previously illustrated, the development of the Zalău Municipality has been highly influenced by geomorphology, the settlement expanding more in the area of morpho-hydrographical convergences. It has thus resulted in a longitudinal form of the built-up area with a few lateral digressions (Porolissum Street and Crasnei Street). Progressively, the main built-up area expanded by adding new urban areas, inevitably more distant from the centre. After the '60s, the industrial development determined an important spatial expansion of the city, even the landforms which had previously represented building obstacles being intensively used for new buildings. However, the most densely build-up area remains the flood plain, which is the most accessible area having low elevation and slopes.

The Zalău Municipality was constrained in its territorial development in a longitudinal shape with consequences on the urban aesthetics, accessibility, transport etc. There are few morphological units which are favourable to constructions (the flood plain and the terraces), therefore the built-up area was expanded even on the slopes. This aspect has determined additional costs and investments and a future direction of necessary building development is towards Meseşeni – Aghireş (PUG, 2007).

The topography has restricted the expansion of the main built-up area, of the edilitary constructions as well as the development of economical activities. The accessibility is low on the surfaces with high declivity and fragmentation, as well as on the ones prone to geomorphological processes, hindering the expansion of buildings and several activities. The flood plain, the terraces and the terraced slopes are favourable for building dwellings, for the transport infrastructure and the technical-edilitary infrastructure. These landforms are accessible and enable the mobility of the population, as well as a wide range of activities.

The layers representing the edilitary constructions and the streets from the built-up area of Zalău, which were created by digitising the recent satellite images provided by the Google Earth database, were included in a spatial analysis performed in a GIS environment and resulted in a global, general view on the building density from the entire city.

The built-up area of Zalău Municipality includes 11 neighbourhoods: Dumbrava Nord, Dumbrava, Simion Bărnuțiu, Păcii, Traian, Centru, Stadion, Brădet, Meseș, Porolissum, Ortelec and 11 new areas: Dealul Morii, Grădina Dochiei, Coada Lacului, Sub Brădet, Sub Dombalja, Merilor, Morii, Grădina Onului, Sărmaș, Între Văi, Valea Miții. The 11 residential areas have been developing since 1990 until present through the construction of individual houses, duplexes and blocks of flats. For these the distribution of buildings per elevation and slope angle class will be identified, as these two morphometric parameters have the highest influence on the building density by favouring or restricting the expansion of the built-up area in certain sectors.

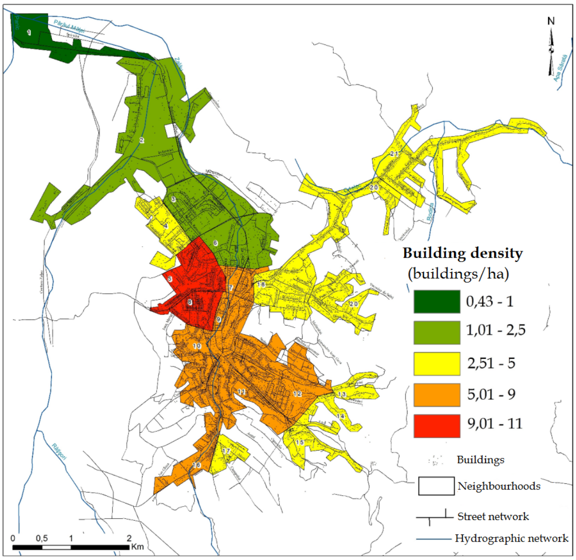

Fig. 2: Distribution of building density in neighbourhoods (where: 1-Între Văi, 2-Valea Miții, 3-Dumbrava Nord, 4-Dealul Morii, 5-Dumbrava, 6-S. Bărnuțiu,7-Păcii, 8-Traian, 9-Centru,10-Grădina Dochiei, 11-Stadion, 12-Brădet, 13-Coada Lacului,14-Sub Brădet, 15-Sub Domblaja, 16-Merilor, 17-Morii, 18-Porolissum, 19-Sărmaș, 20-Grădina Onului, 21-Ortelec, 22- Meseș).

3.1. Density of edilitary constructions in neighbourhoods

In order to determine the number of edilitary constructions located in each neighbourhood and their corresponding density in relationship to the neighbourhood area, functions such as *Zonal Statistic and Intersect* from the ArcMap 10.1 software were used.

High values of the building density were identified (Fig. 2) in the neighbourhoods Traian (11), Dumbrava (9.6), Stadion (8.6), as well as in the residential area Grădina Dochiei (8.04). Low values of the building density characterise the areas Între Văi (0.43) and Valea Miții (3.92). The analysis on neighbourhood *area highlights four areas with* density values between 8 and 11 buildings/ha (Table 1).

A high building density is characteristic to the Traian (11 buildings/ha), Dumbrava (9.60 buildings/ha), Stadion (8.60 buildings/ha) neighbourhoods and the Grădina Dochiei (8.04 buildings/ha) residential area. These high density values are due to low sloped areas, with slope angle values between 2.1-5° which are favourable to buildings, as well as due to a relatively short distance from the city centre and the main transportation route. The neighbourhoods include old and new individual dwellings as well as new semi-collective dwellings (maximum 6 flats). Low density values are present in the areas Între Văi (0.43 buildings/ha) and Valea Miţii (1.01 buildings/ha) because here is where the industrial zone of the Zalău Municipality has developed.

Table 1.

Building density and distribution in Zalău Municipality in relationship with elevation and slope angle classes, for each neighbourhood

Neighbourhoods and residential areas	Building density (b/ha)	No. of buildings on elevation level (m)			No. of buildings on slope angle interval		
		197-280	280.1-345	345.1-414	0-2	2.1-5	5.1-15
Între Văi	0.43	321	2	0	22	8	0
Valea Miţii	1.01	291	1	0	79	137	75
Dumbrava Nord neighb.	2.11	206	16	0	24	123	73
Dealul Morii	3.92	97	111	0	34	155	19
Dumbrava neighb.	9.60	137	359	1	35	262	199
S. Bărnuţiu neighb.	2.48	201	27	0	47	117	64
Pacii neighb.	5.29	148	0	0	46	71	31
Traian neighb.	11.00	155	296	0	9	225	217
Centru	5.52	261	48	0	66	139	104
Grădina Dochiei	8.04	261	286	0	9	143	395
Stadion neighb.	8.60	370	316	0	88	287	313
Brădet neighb.	7.06	190	266	1	3	20	74
Coada Lacului	3.30	0	39	37	0	9	66
Sub Brădet	3.46	21	76	0	69	295	394
Sub Dombalja	4.50	0	101	68	2	60	108
Merilor	5.80	97	196	0	36	149	107
Morii	4.60	13	102	0	6	79	30
Porolissum neighb.	4.32	261	328	0	81	333	175
Sărmaş	4.33	96	180	14	34	119	136
Grădina Onului	4.81	0	111	14	8	69	48
Ortelec neighb.	4.39	33	563	8	164	292	149

3.2. The position of edilitary constructions in relation to elevation

The position of the edilitary constructions in relationship to the elevation and the morphogenetic levels was highlighted through the analysis of minimum, maximum and average elevation for each neighbourhood (Fig. 3). Most of the edilitary constructions from the built-up area of the Zalău Municipality are located on the elevation levels of 197-280 m and 280.1-345 m. The large number of buildings in the elevation class of 197-280 m belong to the Între Văi, Valea Miţii, Dumbrava Nord, S. Bărnuţiu, Păcii, Centru and Stadion areas and neighbourhoods. The Stadion neighbourhood has the largest number of buildings from this elevation class, totalising 370 buildings. The Coada Lacului, Sub Domblaja Grădina Onului areas do not have edilitary constructions on the 197 – 280 m elevation level (Table 1). Păcii neighbourhood has no edilitary constructions in this elevation class, while there is one building in the Valea Miţii area and two buildings in the Între Văi area.

The number of buildings decreases with the elevation increase as the access is more difficult and the prices are higher. A small number of neighbourhoods and areas have edilitary constructions at the elevation level of 345.1– 414 m. The Brădet and Dumbrava neighbourhoods have one building, the Ortelec neighbourhood - 8 buildings and the Sărmaș and Grădina Onului areas - 14 buildings, Coada Lacului - 37 buildings and Sub Domblaja - 68 buildings.

The Zalău Municipality spans over five elevation and morphogenetic levels, from the flood plain to the mountain level.

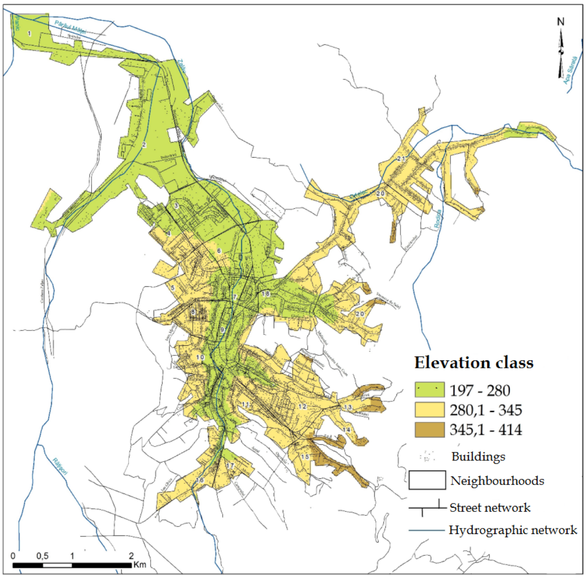

Fig. 3: The distribution of edilitary constructions in relationship to elevation classes

The first relief level corresponds to the flood plain, with the smallest elevation at 197-280 m. Through the predominantly monolateral development on the right side of the valley, the flood plain is asymmetrical, with various width and elevation values. Mostly narrow, the flood plain has a few metres on the Crasna Street, expanding to approximately 200 m in the Liberty Square and reaching its maximum width of approximately 600 m at the river convergence with Ortelec Valley.

Downstream from this point, in the northern part of the built-up area, the flood plain of Zalău Valley develops extensively and asymmetrically, while its width is of approximately 400 m in this sector. The flood plain of Zalău Valley offers the most favourable conditions for buildings. Thus, this sector is completely developed for various urban purposes. A large part is built-up with dwellings and storage spaces as well as roads. In the northern part of the built-up area where the Zalău Valley is at its largest, the industrial zone was developed, as well as the railway station, the third street node and the railway.

The second relief level is characterised by an elevation between 280.1 and 345 m and corresponds to the terraces and the terraced slopes. *The terraces* from the study area are characterised by monolateral distribution, a scarce presence of superior levels and the existence of a thick gravel layer. The hilly area with predominantly sloped surfaces, as well as horizontal and quasi-horizontal surfaces, define the terrace treads. In the study area one identifies the terraces of 8-10 m, 25-35 m and 50-55 m (Mac, 1996), on the left side of the Zalău Valley. Dumbrava and Dumbrava Nord neighbourhoods are located on the 8-10 m and 30-35 m terraces, in the north-western part of the built-up area. Some dwellings have been extended up to the upper terraces (50-55 m) and on the slopes, which lead to the development of stepped apartment blocks, edilitary works and access ways which are perpendicular to level curves. This has lead to an increase of the value of investments as well as to an alteration of the terrace shape. The third relief level is set between 345.1 and 425 m and includes the foothill level, in the Paramesesan Foothill. The fourth level expands in the mountain area, forming the foot of the mountain between 425.1 and 534 m. The fifth level continues into the mountain area and belongs to the Meseș Mountains, between 534.1 and 727 m (Vâtca et al., 2014).

3.3. The position of edilitary constructions on slope angle intervals

The position of edilitary constructions on each slope angle class was determined using the *Zonal Statistic and Intersect* functions from the ArcMap 10.1 software. The buildings are distributed on the following slope intervals: 0-2, 2.1-5, 5.1-15 and 15.1-17.2º (Fig. 4). The majority of edilitary constructions in the Zalău built-up area are located on the slope intervals of 2.1-5º and 5.1-15º. The Ortelec neighbourhood has the largest number of buildings on the 0-2º slope angle interval. On the other hand, in the residential area Coada Lacului there is no building in this slope interval. The largest number of buildings in the interval of 2.1-5º is located in the Porolissum neighbourhood, totalising 333 buildings, followed by the Sub Brădet area with 295 buildings and Ortelec neighbourhood, with 292 buildings.

As one can notice in table 18, there is a decrease in the number of buildings with the increase of slope angle. On the slope classl of 5.1-15º there is no building in the Între Văi area, while Valea Miții and Dealul Morii areas and Păcii neighbourhood own the smallest number of buildings from their total. The exception from this rule is represented by Grădina Dochiei and Sub Brădet areas as well as Stadion neighbourhood which have the largest number of buildings (395, 395 and 313, respectively) from their total number being built on a slope of 5.1-15º.

The slopes between 5.1° and 15° represent approximately 62% of the total surface and are found on delluvial glacis. Higher slope angles (>15.1°) are found in the contact area of the Silvaniei Hills with the mountains, but also at the slope basis. These surfaces are prone to linear geomorphological processes and to landslides and are restrictive to buildings and agriculture.

Slopes are a major part of the urban landscape and represent the landforms on which most of the restrictive geomorphological processes occur inside the built-up area, hindering the urbanising of certain sectors (Mac, I., 2010). Nevertheless, slopes are highly capitalised on in the process of urban development and expansion in the Zalău Municipality.

Cuestas are present on the right slope of the Zalău Valley, but also on the slopes of the secondary valleys, depending on their slope aspect. They have small sizes, their height rarely surpassing 100 m. Cuestas also belong to the Parameseșan foothill landscape, highlighting the steep hillslopes towards the subsequent depressions of Stânei and Ciumărnei.

Cuestas represent the landforms with the lowest favourability for anthropogenic activities. They have a high slope angle, of over 10°, the dynamics of the slope processes is accelerated, the water resources are scarce and the access is difficult. Due to all these, cuesta slopes are used for vineyards and orchards (Ciumărna). The deforestation of these surfaces has also accelerated the activity of slope processes.

3.4. The position of edilitary buildings in relationship to landslide susceptibility

Thematic maps of each factor responsible for the occurrence and evolution of landslides, representing the risk coefficients, were created using an integrated information system (GIS technology). The estimation of value and geographical distribution was performed for each risk coefficient separately: lithologic, geomorphological, structural, hydro-climatic, hydro-geological, seismic, sylvic and anthropogenic, thus generating the map of the average hazard coefficient (Vâtcă et al., 2014).

Further, starting from the database comprising the building and transport infrastructure, the spatial distribution of edilitary constructions on neighbourhoods was analysed according to the potential of landslide occurrence determined through the methodology described in H.G. 447/2003. To increase the applicability of the model, the analysis was performed at neighbourhood level. Thus, for each neighbourhood of Zalău a minimum, average and maximum value of the hazard coefficient was determined according to the present legislation. The maximum value of the medium hazard coefficient for each neighbourhood ranges from 1.693 to 2.146 (Fig. 4). The lowest values of the coefficient are found in the newly-built areas from Zalău: Grădina Dochiei, Sub Brădet, Cascadei, Sărmaș and Grădina Dochiei. Valea Miții is the area with the highest coefficient value per neighbourhoods.

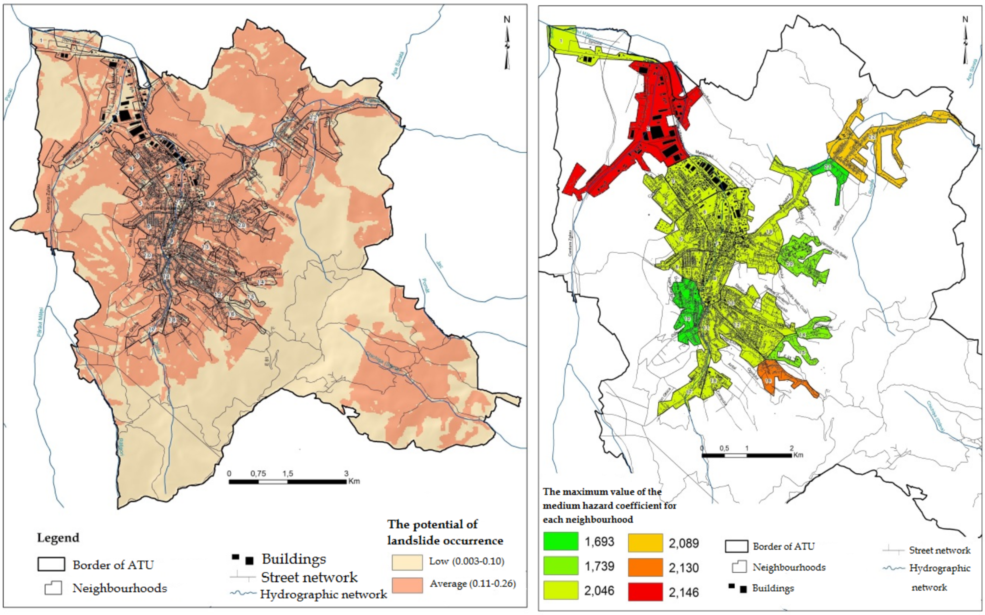

Fig. 4: Spatial distribution of edilitary constructions in Zalău according to the potential of landslide occurrence in each neighbourhood (left) and in each class of medium hazard coefficient (right).

By visually and statistically analysing the average probability of landslide occurrence per neighbourhoods, one notices the largest number of edilitary constructions in the areas with average potential of landslide occurrence (Fig. 4). The smallest average values of the medium hazard coefficient per neighbourhood are found in the Ortelec neighbourhood, in the Între Văi and Sub Brădet areas, with values between 0.928 and 1.192. The highest average values of the medium hazard coefficient per neighbourhood are found in the Stadion, Dumbrava Nord, Simion Bărnuțiu and Traian neighbourhoods, with values between 1.541 and 1.619. The rest of the neighbourhoods from Zalău Municipality have an average value of the medium hazard coefficient per neighbourhood ranging between 1.269 and 1.526.

4. GEOMORPHOLOGICAL RISK AFFECTING URBAN DEVELOPMENT

Risk represents "the probability of harmful consequences, or expected losses resulting from interactions between natural or human-induced hazards and vulnerable conditions" (UNISDR, 2001). The study of risks is essential in the planning stage and the development process of a settlement.

Among the risks affecting urban development, the geomorphological and flood risks are pre-eminent in the Zalău Municipality (Fig. 5). The city of Zalău has four categories of geomorphological risk. The flood plain has no geomorphological risk, the average risk is associated to terraces, the mountain area has a moderate risk level, while a high risk level is present in the foothill area.

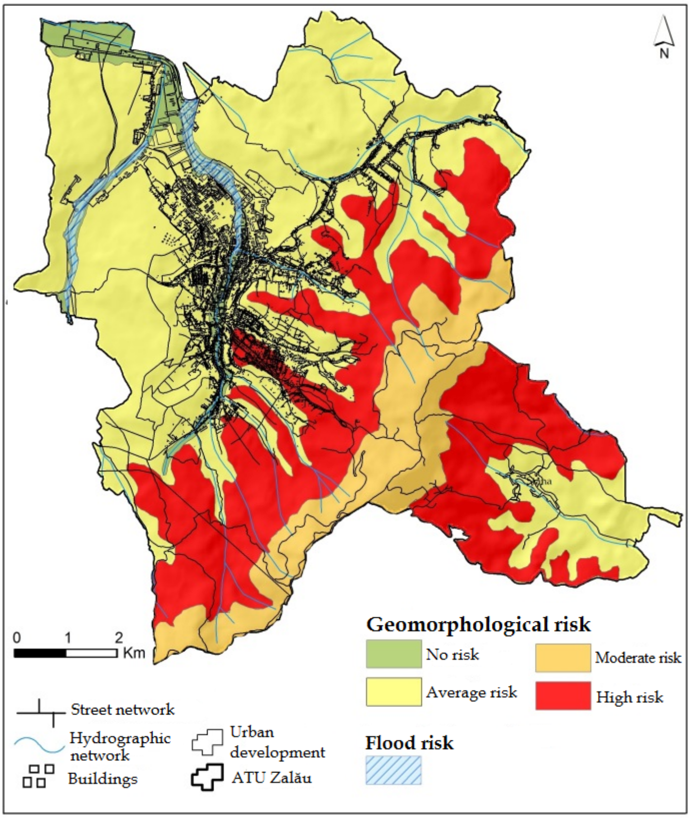

Fig. 5: Geomorphological risk map of the Zalău urban area

When analysing the percentage distribution of the risk classes in the administrative territory of Zalău, the expansion of the high risk class reaches 47% of the analysed surface. This class characterises mostly the foothill area of the analysed territory and has specific morphometric elements (slope angle, elevation).

The slope aspect and land use determine the occurrence of geomorphological processes, such as: landslides, rills, gullies, soil erosion. These processes cause material damages of the building and transport infrastructure.

The moderate risk class mostly characterises the mountain area, representing 8% of the analysed territory. Although specific geomorphological processes occur due to the low density of buildings and infrastructure elements, the effects are moderate.

In the case of the major riverbed of the Zalău Valley and Miţii Valley, the geomorphological processes have a moderate intensity. However, this does not eliminate the possibility of other risks affecting these surfaces. The upper sector of the Miţii Valley is affected by flood risk, while the central zone of the Zalău Municipality is also included in the flood risk zone due to the presence of flash floods on slopes.

5. CONCLUSIONS

The use of GIS technology in generating the detailed digital maps of the study area starting from the topographic maps of 1:25 000 enabled the creation and analysis of the various morphometric maps of the city topography. The analysis of geodeclivity, hypsometric levels and building distribution on the main landforms per classes of landslide occurrence are all important endeavours in the identification of the favourability to anthropogenic activities for the expansion of build-up area and the assessment of vulnerability.

The morphometric characteristics of the topography are important in the process of urban planning. The identification and analysis of the morphometric data offered important details on the landscape dynamics enabling the sustainable planning of the analysed territory by avoiding the areas prone to geomorphological hazards.

Acknowledgments: This paper is made and published under the aegis of the Research Institute for Quality of Life, Romanian Academy as a part of programme co-funded by the European Union within the Operational Sectorial Programme for Human Resources Development through the project for Pluri and interdisciplinary in doctoral and post-doctoral programmes Project Code: POSDRU/159/1.5/S/141086.

R E F E R E N C E S

1. Mac, I. (1996), *Influența reliefului în dezvoltarea, sistematizarea și estetica urbană a municipiului Zalău*, Studia UBB, Geographia, Cluj-Napoca.
2. Mac, I., Hosu, M., (2010), *Constrângeri, praguri și stări environmentale de risc în Municipiul Zalău*, Riscuri și catastrofe, Cluj-Napoca.
3. Nicoară, L., (1998), *Dealurile Crasnei. Studiu de geografia populației și așezărilor umane,* Teză de doctorat, Cluj Napoca.
4. Petrea D., Bilaşco Şt., Roşca S., Vescan I., Fodorean I., (2014) *The determination of the Landslide occurence probability by spatial analysis of the Land Morphometric characteristics (case study: the Transylvanian Plateau)*, Carpath J Environ Sci 9:91–110
5. Petrea, Rodica, (1998), *Dimensiunea geomorfologică în dezvoltarea și estetica urbană a orașelor mici din Dealurile de Vest (sectorul dintre Barcău - Crișul Negru)*, Editura Universității din Oradea, Oradea.
6. Roşca S., Bilaşco Şt., Petrea D., Fodorean I., Vescan I. & Filip S., (2015), *Application of landslide hazard scenarios at annual scale in the Niraj River basin (Transylvania Depression, Romania),* Natural hazards, *76:* DOI 10.1007/s11069-015-1665-2
7. Vâtca, A. (2014), *Municipiul Zalău. Morfologia și amenajarea spațiului urban*, teză de doctorat, Universitatea Babeş Bolyai, Cluj Napoca
6. Vâtca, Andreea, Roşca, Sanda, Deac, Simona (2014), *The role of the relief in the evolution, structure and functionality of the Zalău urban area*, Geographia Napocensis VIII (2):41-48.
8.Vâtca, A., Irimuș, I.A., Roşca, S., (2014), *Landslide susceptibility in Zalău Municipality,* Revista de Geomorfologie, 16:37-44.
9. *** (2001), *UNISDR Terminology on disaster risk reduction,* UNISDR, Geneva
10. *** (2003*), HG nr. 447/2003, privind aprobarea normelor metodologice privind modul de elaborare și conținutul hărților de risc la alunecări de teren*, Secţiunea V– Zone de risc natural, Parlamentul României, publicată în Monitorul Oficial, nr. 305 în 7 Mai 2003. Available at: *http://lege5.ro/.../ hotararea-nr-447-2003-,* Last accessed: August, 22, 2013.
11. *** (2006-2007), *Plan urbanistic general și regulament local de urbanism*, Primăria Municipiului Zalău.