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Identifying optimal locations for mobile first aid facilities in Bucharest, accounting for seismic risk

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Abstract. In case of a major earthquake in the Vrancea area, Bucharest can be significantly affected (as it happened in 1940 and 1977). As highlighted by these events, the need for establishing mobile first aid facilities close to affected areas (deployment of medical containers or mobile hospitals) is expected to be of high importance for saving lives. In this research we identify the need of such facilities and the favorable locations, considering multiple earthquake scenarios. Our methodology is based on multicriteria analysis in which we use the SMCE module of the ILWIS geospatial program and take into account three indicators: (i) the estimated losses in terms of affected residential buildings and occupants, calculated for 3 earthquake scenarios, (ii) distances from buildings with high seismic risk levels (categories I and II) and from important traffic routes, and (iii) road network connectivity loss after a major earthquake. The results identified the central and peripheral area as having complex issues and the need for future analyzes at the neighborhood level.

Keywords: *first aid, emergency management, earthquake, Bucharest, disaster risk*

1. INTRODUCTION

The city of Bucharest is probably **Europe's highest seismic risk capital city** (Pavel and Vacareanu, 2016; Toma-Danila and Armas, 2017). Previous earthquake experiences (such as the one in the Vrancea Area on 10 Nov 1940 with moment-magnitude Mw = 7.7 or 4 March 1977 with Mw = 7.4) and the current situation support this statement (Fig. 1). A first aspect is represented by the **vulnerability of buildings** – currently 349 buildings have been examined and classified in seismic risk class I, out of a total of 856 examined buildings (PMB, 2020). Beside these, statistical data from the 2011 National Census indicate that there are currently **many more old buildings that could be highly vulnerable**: around 10% of the total residential buildings were built before 1963, a period in which there were no compulsory seismic design codes in Romania.

Bucharest is the most important industrial, commercial and administrative center in Romania and the city with the highest number of inhabitants – there were 2,112,483 inhabitants in 2018 (INS, 2018). Times have changed (compared at least with 1977) **road traffic could pose a significant additional risk in disaster situations**. There are over 1.2 million registered vehicles (INS, 2018). A study by TomTom (2019) places Bucharest in the 4th place in Europe (1st in EU and 14th in the world) in terms of road congestion level. That is why we also felt important to take this factor into account in our analysis.

2. OBJECTIVE AND METHOD

The objective of this study is to identify the need and optimal locations for first aid facilities in case of seismic disaster at full Bucharest city level, by applying the multicriteria method. These facilities must be able first of all to accommodate specific containers with the necessary equipment for first aid. The analysis took into account the intervention times in case of disaster, parking lots of over 1000 sqm as potential favorable locations, the seismic vulnerability of the built space, and the socio-economic and environmental vulnerabilities.

A new methodology was used to **identify the distribution of emergency response times and areas that may become difficult to access** in major earthquake conditions in Bucharest, as defined in Toma-Danila (2018) and Toma-Danila et al. (2020). This methodology is integrated in a toolbox for ArcGis called Network-risk, which allows the calculation of intervention times by modeling the implications of an earthquake on the road network: directly, taking into account the probability of collapse of structures and blocking road segments, as well as indirectly, taking into account the redistribution of traffic. The variability of possible situations is analyzed using a Monte Carlo simulation, including considerations regarding typical traffic on a Monday at 2 AM, 8 AM and 6 PM. The considered locations of the emergency response crews are those of the emergency hospitals (with an emphasis on category I emergency hospitals) and of the fire brigades. The road network data used for Bucharest comes from OpenStreetMap, as of January 2016. In total, 50,412 individual road segments are individualized and used.

As a result of this approach, **the final map of qualitative assessments of potentially inaccessible road areas in case of earthquake** for the 3 traffic scenarios and for a combination of values obtained from the worst possible scenarios and random scenarios selected by the Monte Carlo method is included in the location analysis.

The site analysis is limited to a general identification of needs at city level in relation to the areas suitable for this purpose, depending on the requirements of providing first aid for disasters. To this end, the **parking lots with an area equal to or larger than 1000 sqm**, shown in *Figure 2*, were selected at city level.

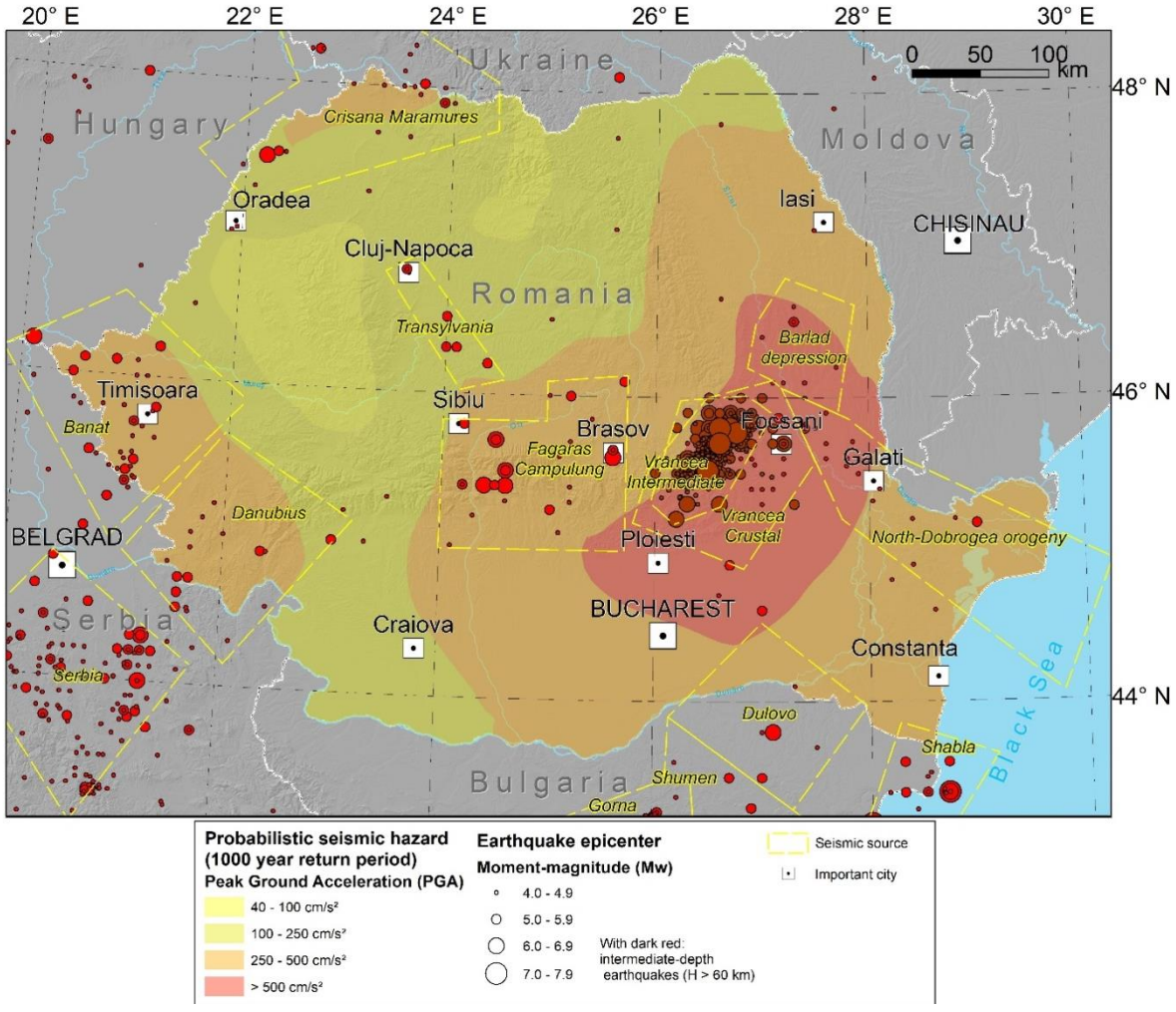

Fig. 1 Earthquakes in Romania and the main seismic sources (according to the Bigsees Project, 2016), as well as the seismic hazard (according to the Ro-Risk Project, 2017) calculated probabilistically, for a 1000 year return period

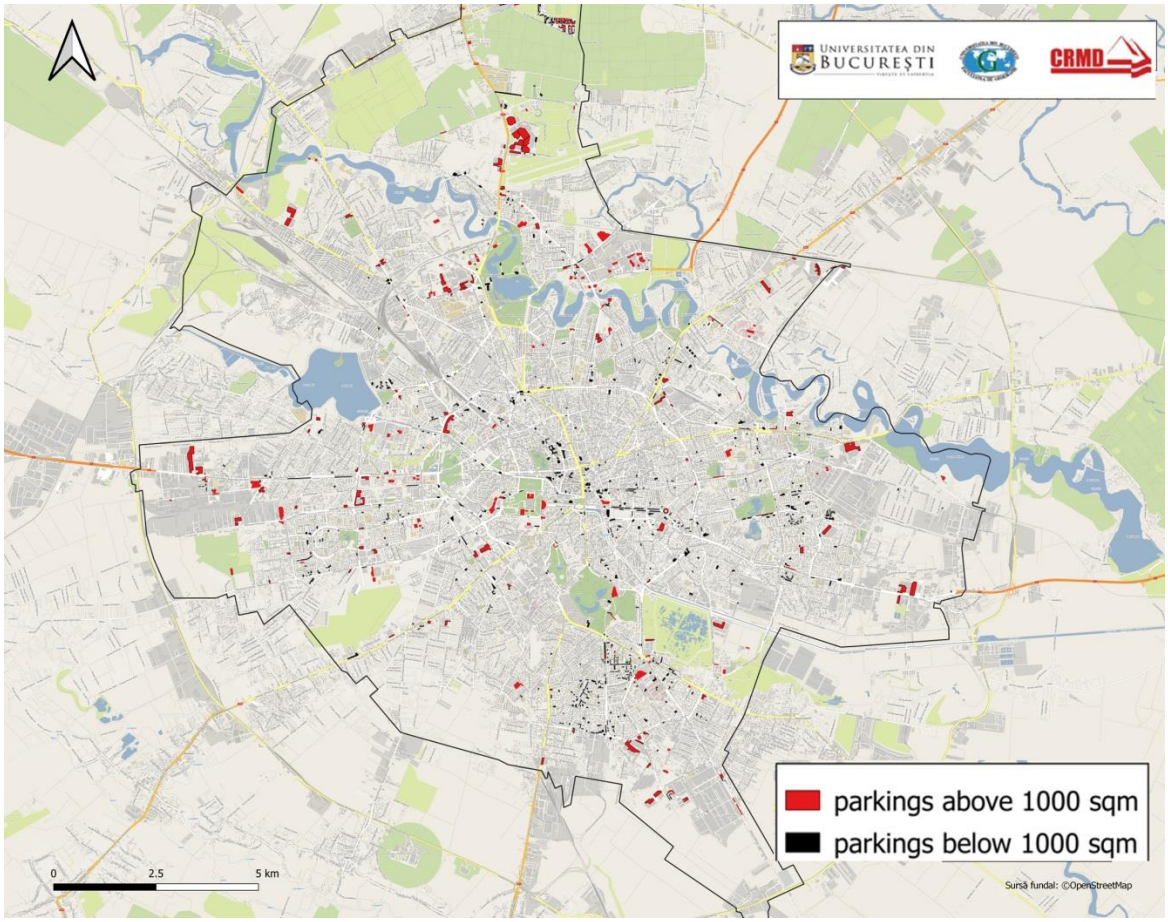

Fig. 2 Map of parking lots with an area equal to or greater than 1000 sqm

Within the administrative limit of the city of Bucharest there are 242 parking lots of over 1000 sqm. However, these locations must be studied individually according to the criteria of safety and accessibility in case of disaster, and also to the first aid need in the area. Many of these car parks meet the requirements of the spatial analysis, but a detailed assessment indicates that they serve blocks of flats, being overcrowded and vulnerable in the event of a building collapse.

The categories of car parks identified in Bucharest are: **Commercial** – private car parks belonging to shopping centers (including street markets, malls, supermarkets and hypermarkets), **Public** – public car parks (free-of-charge or paid), **Public institutions** – the private car parks of public institutions, **Private** – private parking belonging to companies, **Residential** – private parking for the residents of residential neighborhoods, **Depots** – private parking of the Bucharest Transport Company (including bus bases), **Military Institution** – parking within the Land Forces bases, **Airport** – parking at Baneasa Airport, and **Embassy** – the private parking of the US Embassy.

The general analysis of the selected locations shows an uneven distribution, different from one sector to another, so most parking categories are found in sector 1 (8 categories), and the least in sector 3 (4 categories).

The most suitable locations for the purpose of the study are commercial parking lots, which are quite large and the number of cars parked long-term is low. They are also not surrounded by tall buildings, which could collapse in a strong earthquake, reducing the usable area of the car park by 20% of the volume of the collapsed building. Also suitable would be the parking lots belonging to the Bucharest Transport Company, because they occupy extensive areas, usually located away from tall buildings.

An **overall analysis of favorable large car parking areas** in relationship to the 2011 census districts was made, taking into consideration **the environmental conditions, the seismic hazard, the overall construction vulnerability of the**

buildings, the social and economic conditions and vulnerabilities, the estimated risk calculations, the flood risk map of the city in the case of a dam rupture scenario (e.g., Armaș, 2012; Armaș and Gavriș, 2013; Armaș et al., 2016, 2017; Gogoașe Nistoran et al., 2019; Zaharia et al., 2016)**, and the risk analysis in different earthquake scenarios in Bucharest**.

In the analysis of the relationship between the possible container locations and the site-specific conditions, the following additional data was included:

- **areas qualitatively assessed in terms of the vulnerability of response times** in the event of an earthquake, for intervention crews (ambulances and firefighters), as well as areas that may become inaccessible (likely to become so). For this analysis, the locations of all police stations, hospitals, firefighters, and ambulance stations in the city were processed.

The main focus of the analysis was on the difficulty of accessibility in post-earthquake conditions for emergency services – ambulances, firefighters or SMURD crews, which are major players in reducing the number of victims and thus the seismic risk.

- **buildings in seismic risk class I** (according to the official list from the City Hall from January 2016), in order not to jeopardize the access to the location of the container locations or even to endanger their positioning through major risk of collapse. At the same time, it was taken into account that the selection of locations should be in the vicinity of areas with a high density of these buildings with major seismic risk.
- **estimates of damage at the census unit level** (with cut-outs for areas without residential buildings), made with the help of Seisdaro System – the SELENA software based module (Toma-Danila et al., 2018) using exposure data from 2011 and two representative earthquake scenarios: 1977, and the Bucharest microzonation map for a strongest possible earthquake scenario for Vrancea Area (Marmureanu et al., 2010). Averaged estimates for completely affected buildings and worst-case scenario number of deaths and severe injuries (Toma-Danila and Armas, 2017) were considered.

3. MULTICRITERIAL ANALYSIS IN IDENTIFYING THE FAVORABLE/ UNFAVORABLE POTENTIAL OF LOCATION POINTS

The **multicriteria spatial analysis module (SMCE) of the ILWIS geospatial program** was used in the analysis of the relationship between generic location areas at city level, depending on the dimensional criteria and environmental conditions. This multicriteria analysis involves the use of data (qualitative or quantitative) to saturate the selected analysis indicators (criteria) and combine them according to their importance for the proposed aim. The purpose of our analysis was to scan at city level and identify the favorable/ unfavorable locations for first aid facilities, depending on major vulnerability and risk criteria. However, the resulting image must be interpreted considering the needs of the city, respectively: **the unfavorable areas for the location are those where the demand for first aid points is high**. This is because these areas are hot spots of seismic risk, which will involve collapsed buildings and human casualties.

As a methodology, the used data for each indicator **highlights the favorable or unfavorable areas for the site** and the combination is made using a criteria tree that weighs the importance of each indicator (criterion) in the final result (final map of unfavorable/favorable identified sites).

The multicriteria tree was designed on three criteria/indicators:

1. *Traffic vulnerability and probability of blocking/isolation of certain areas*
2. *Analysis of distances from buildings with seismic risk I and II and from important traffic arteries*
3. *The potential direct seismic losses (residential buildings and population), calculated based on two earthquake scenarios.*

The traffic vulnerability indicator is composed of the vulnerability index according to the intervention times for ambulances and firefighters and the index of obstructed areas. The response time index is composed on a scale from 1 to 5, where *1 means low vulnerability* – usually reached in a maximum of 10 minutes to the intervention, both by ambulance and firefighters – the average of

3 scenarios of which 1 without traffic, and *5 is very vulnerable* – it cannot be reached in less than 25 minutes (ambulances and firefighters). The probability of being blocked in traffic highlights areas that are difficult to access by the intervention crews, blocked mainly due to collapsed seismic risk class I buildings (20% to 90%). The analysis took into account the distance index from these areas with a high probability of remaining blocked and isolated in the case of the 3 earthquake scenarios.

The distance indicator contains as a *favorable aspect* the location of the containers in the proximity of the main arteries (the accessibility criterion), and as an *unfavorable aspect* for the location, the proximity to the buildings with seismic risk. Distances from buildings at risk of collapse were interpreted as an impediment to the establishment of sites. A distance of *500 m* is the minimum from the respective buildings to make the location favorable, and the distance from the large arteries was interpreted as a benefit index (the longer the distance, the harder it is to reach). The empty weighting method was used, setting a maximum limit of *500 m* for favorability.

The potential direct seismic losses are represented by the average vulnerability of buildings at city level and by the maximum percentage of population loss (dead and seriously injured), in the case of the two earthquake scenarios.

As a normalization, for the indices that make up indicators 1 (*Traffic Vulnerability*) and 3 (*Potential direct seismic losses*), benefit normalization was used at intervals, to highlight the finest differences in the data string of the unfavorable footprint for locations.

The weighting at the level of the 3 indicators was direct, giving more importance to the blockage of some arteries and the isolation of some areas in the city due to the collapse of buildings for the *traffic indicator*, the proximity of buildings with eminent risk of collapse in case of the *distance indicator* and the percentage of human casualties in the total population of the constituency in the case of *indicator 3*.

When agglutinating the indicators in the final map of unfavourability/favorability of each location, the 3 indicators were given equal weights.

Parks, vacant, agricultural, and unbuilt lands were removed from the analysis and appear in white in the final map, but during a later analysis, some of them may come into question as possible locations, except for those along the Dâmbovița river, which are at risk of flooding.

The parking lots with over 1000 sqm are shown in black on the map in *Figure 3* and the limits of the 2011 constituencies have been shown for better localization. Since the legend was set so that high values (towards red) indicate unfavourability in locations, it is found that the central area is the most restrictive from this point of view, presenting the possibility of traffic jams and isolation of areas, having a high vulnerability of buildings and a high density of buildings framed with seismic risk, generating possible loss of life in the event of a disaster. However, this is the area with the greatest need for such first aid points. Diametrically opposite, the most favorable areas of location prove to be those in blue on the map, which approach no problems related to the selected previously presented indicators and their processing. This result underlines even more obviously the need for localized, detailed analysis, with updated field data for each type of situation.

4. RESULTS

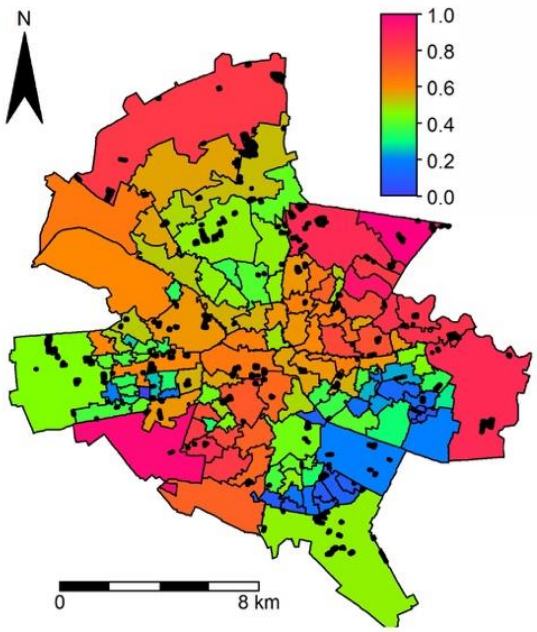

Fig. 3 The overall building vulnerability

The average overall building vulnerability (1 = total destruction) and the distribution of spaces representing parking lots at city level are shown in *Figure 3.* The problem of the central area, but also of the peripheral one is observed, where neighborhoods such as Bucureștii Noi, Străulești, Rahova, and Ferentari, characterized by single-family suburban houses embedded in the city structure, have a high seismic vulnerability, doubled by lack of favorable locations to first aid points.

The number of houses in each census district is shown in *Figure 4*, in relation to the distribution of car parks (white areas represent areas without residential buildings, including parks and vacant land). To be observed is the concentration of a maximum number of houses in the peripheral areas, embedded in the urban fabric, but keeping its rural character. The high density of houses, delimited by narrow streets, is doubled by the lack of open spaces favorable to the locations of first aid points.

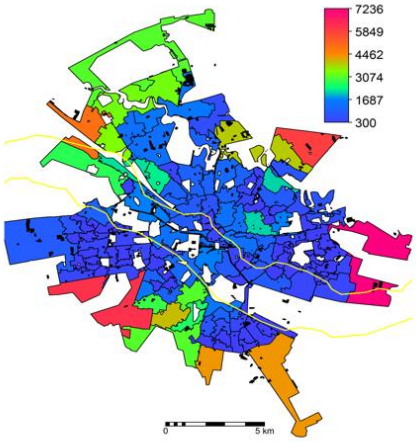

Fig. 4 Total number of houses

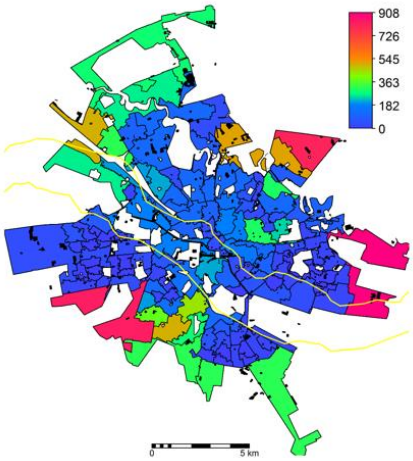

Fig. 5 Number of houses estimated to be severely damaged

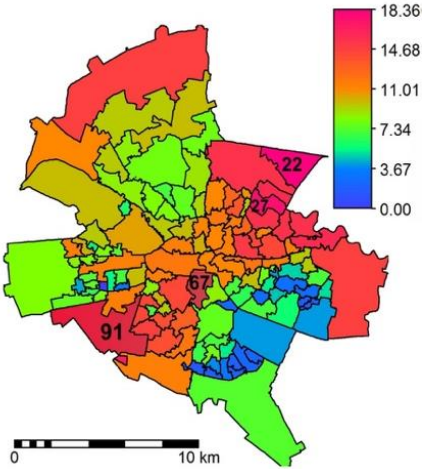

Fig. 6 Total loss %

The number of houses severely damaged in the event of the strongest possible earthquake is shown in *Figure 5*, in relation to potential parking lots. Of course, disaggregation of buildings per height regime provides a more representative image of the potential need for first-aid assistance, but this is reflected in *Figure 6*.

In *Figure 6* there is the maximum losses among the overall number of buildings according to the 2011 census districts, shown as a percentage of the total buildings in the district. There is a concentration of these losses in the same peripheral areas previously identified as part of the peri-urban rural fabric embedded in the city. In these areas, cheap houses, made of brick or even mudbrick, predominate. They are crowded in family compounds, in almost non-existent yards. They line up on narrow streets, sometimes only 2-3 m wide, in many situations unpaved and without sewage systems.

In this landscape with a predominantly rural imprint of buildings, residential blocks of flats are built from place to place, with 5 to 8 floors, without adequate spaces between buildings, delimited by clogged streets, sometimes without sewers. We do not have information about the observance of construction norms in these residential complexes but their height enters the spectrum of the seismic vulnerability of the city (buildings with over 4 floors).

It is often difficult for fire trucks to enter the space between the blocks that form these residential complexes, with alleys much undersized to maximize profits and devoid of green spaces.

At city level, there are 4 constituencies with a maximum overall building vulnerability, lined up in a NE-SW direction through the entire city: 91, 67, 27 and 22 in *Figure 6*.

These districts include both the situation of cheap houses on the outskirts of the city, and the area of Cosbuc Square – Carol Park, with historic brick buildings, in a state of advanced degradation, sometimes even in ruins.

The estimated number of people severely injured and killed in the event of the maximum possible earthquake scenario is shown in *Figure 7* in relation to the positioning of car parks and the flood mask.

The share of the affected population from the total population of the constituency in a maximum possible earthquake scenario and in relation to all parking lots in the city is shown in *Figure 8*.

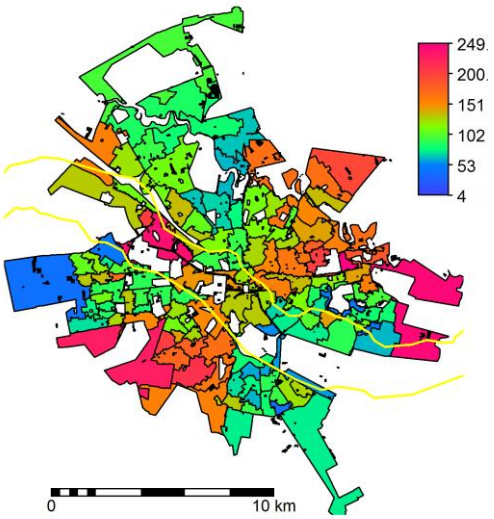

Fig. 7 Total number of severely injured and deceased, for the maximum possible earthquake scenario

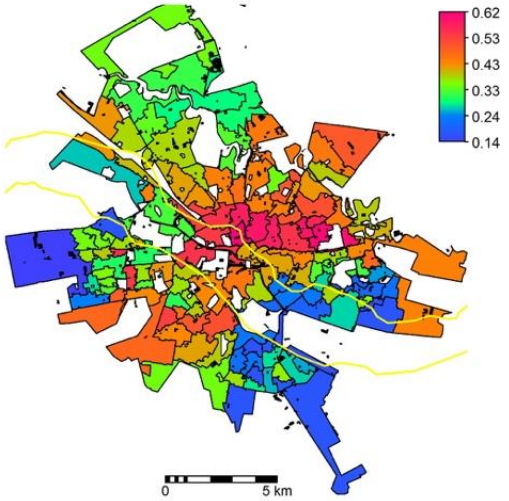

Fig. 8 The share of the severely injured and deceased in the total population of the constituency, for the maximum possible earthquake scenario.

It is observed that the central and peripheral areas can be the most affected. The absolute number of severely injured and deceased estimated in Figure 7 represents more than half of the resident population in the respective constituencies. Being predominantly residential areas, a difference will appear depending on the time of the catastrophe, with a maximum of affected population in the evening/night scenario, when the inhabitants willbe mostly at home (the worst-case scenario that we used).

Considering the visual interpretation of the spatial results, there is a concentration of buildings with seismic risk 1 in the historic center, along with a small number of parking lots that meet the condition of placing the containers. At the same time, the high density of constructions, many of them historical, is not completed by the presence of green spaces with wide openings, especially outside the area at risk of flooding in the Dâmbovița meadow.

The map detail (*Figure 9*) for the city center, shows the high and very high vulnerability of the buildings, the high population vulnerability and the lack of optimal spaces for the location of first aid points.

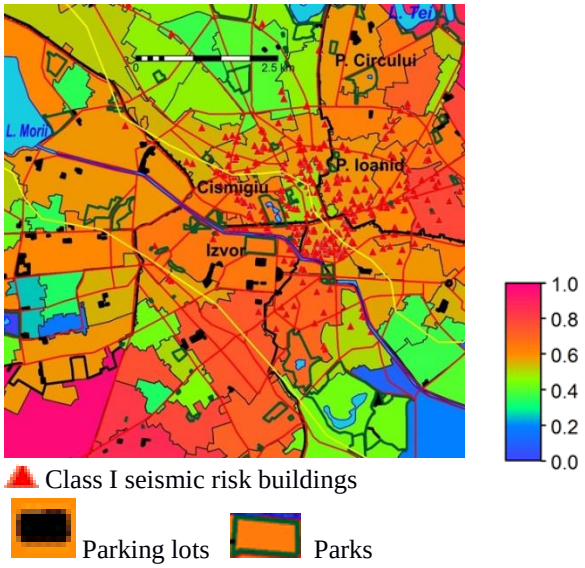

Fig. 9 Vulnerability map detail

5. CONCLUSIONS

In this analysis, the most important selection criteria are based primarily on the proximity of the areas with many buildings potentially affected by a major earthquake (although taking into account only class I seismic risk buildings is not sufficient – in reality there being many more vulnerable buildings not yet seismically examined, many of them also in the central area of the city). Another criteria was to maintain road accessibility in the event of an earthquake (connection with the rest of the city) and also to consider the available space (1000 sqm) for the installation of specific first aid points for emergencies.

Even though during previous major earthquakes problems in Bucharest appeared in the city center due to the collapse of buildings of moderate and

medium height, and road traffic was not significantly affected, since the number of vehicles was not high, we believe that this situation could be totally different nowadays.

The city center can be considered as presenting the highest risk, due to the dysfunctions of the road networks. Even with the Colțea Hospital and the Mihai Vodă Fire Department present in this area, the many small streets and many old buildings significantly limit the choices for alternate routes.

The process of identifying the needs of the location of first aid points in emergency situations in Bucharest will have to be continued through a neighborhood by neighborhood analysis and will involve the application of decisional analysis to choose the optimal locations based on a participatory method, by weighting all the interests and needs of those involved.

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A short review and selection of soil erosion models

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Abstract. The article gives a brief review of the related literature concerning soil erosion by surface water flow and provides an outline of several currently available models. They are analyzed in terms of their model structure and spatial and temporal resolution. The focus was on selecting a number of three model approaches that potentially could be applied to the upper and middle sectors of the Prahova River Valley.

Keywords: *soil erosion models, RUSLE- 3D, USPED, SPL, Prahova Valley*

1. INTRODUCTION

Soil erosion is a widespread form of soil degradation, and it has a considerable environmental and economic impact on different scales. Even though erosion is a process shaped by natural factors, current anthropogenic interventions within the landscapes often accelerate natural erosion rates staggeringly. The determination of soil loss predisposition within a valley is considered a significant theoretical and practical issue, the knowledge of it creating premises for better risk management. Effective modeling can provide information about current erosion, its trends, and scenario analysis (Ganasri and Ramesh, 2016).

It is well known that water erosion processes occur at different intensities across the landscape. However, the spatial and temporal scales of the processes are still poorly understood, which assesses of soil erosion a complex and difficult task, with considerable uncertainties. As a consequence, there is a need to improve the understanding of erosion processes at the field, catchment and larger regional scales from the quantitative perspective, in order to be able to analyze their on-site impact on soil productivity as well as their off-site impact on streams (e.g., sedimentation and water quality) (Wickenkamp et al., 2000; Romero and Stroosnijder, 2002).

Localization of erosion-prone areas and quantitative estimation of soil loss rates with sufficient accuracy is of great significance in creating premises for better risk management and implementing appropriate erosion control and soil conservation practices (Shi et al., 2004). Equally, erosion research is important to enhance understanding of landform development across temporal and spatial scales (Slattery et al., 2002; Wainwright et al., 2003).

Although over the last 20 years there has been impressive progress in the development of mathematical tools for erosion modeling, several important issues remain unsolved, as follows (Saavedra, 2005):

(i) Many current methods require a large number of experimental input data which is unavailable.
(ii) The need to integrate model algorithms that consider all the effects of terrain shape.
(iii) The need to integrate model algorithms across distinctive spatial and temporal scales.
(iv) The need to validate both spatial and quantitative aspects of model predictions.
(v) The continued need for experimental research for deriving soil and land cover input parameters for process-based erosion models.

2. SIGNIFICANCE OF SOIL EROSION FOR THE STUDY AREA

The upper and the middle sectors of the Prahova River Valley is an important socio-economic region that contains infrastructure connecting the southern and northern regions of Romania. This area is heavily affected by slope and river processes related to the growing demand of an expanding population leading to an intensification of house building and road construction.

Generally, there is a good qualitative understanding of the main causes of soil erosion at the local level. Nonetheless, research is required to get more of the quantitative information needed for predicting potential soil erosion in order to design and select the proper management solutions. While soil erosion rates based on field measurements are not available at the catchment or regional scale, they may be monitored at a plot or field scale. Even so, such data is often not comparable because of non-standardized methodologies and, non-uniform experimental conditions.

3. SPATIAL SCALE AND SCALING

The scale has great importance in soil erosion modeling and policy making because it influences model development and selection, as well as data availability and quality.

Models perform at certain scales, but not necessarily those matching the process or observation scales. Scaling is an adjustment in either spatial or temporal scale and has a certain direction and magnitude (Bogena and Diekkrüger, 2002). It evaluates modifications in the characteristics of an object or process when its scale is changed proportionally. The gathered data used in such studies can be generalized or simplified based on dominant properties and processes, and on the spatial and temporal variability at the scale of interest. The process, if simplifying complex geomorphologic phenomena into distinct units, is often referred to as regionalization (Bernert et al., 1997). Hence landscapes are spatially heterogeneous areas; each regionalization method has to be developed in such a manner that it fulfills the requirement for a specific scale (Turner, 1989).

One of the major challenges in soil erosion modeling, when applying the concept of scaling, is to identify how topographical attributes change if the spatial resolution of the digital model (DEM) is modified. (Zhang et al., 2002). Vigiak (2005), Xia, and Clarke (1997) report that a common concern is that the parameters build on a scale or several different scales are input into a model that operates on another scale. Although it is difficult to scale a complex ensemble of parameters and models to corresponding process scales, it is feasible to identify several scalable parameters within the complex erosion processes to improve the model accuracy (Pecknold et al., 1997).

4. TEMPORAL AND SPATIAL VARIABILITY

Simple empirical erosion models estimate relatively steady, long-term erosion based on statistical analysis from long-term observation. Factually, erosion rates are highly dynamic and challenging to capture due to the limited resolution of the input data and complex, multiscale interaction. More sophisticated models can perform continuous time simulations of several interacting processes that incorporate steady-state impacts of rainfall events over several years. However, they require types and scales of data that usually are unavailable.

Soil erosion can be dominated by a few extreme events. However, low magnitude, high-frequency events can also have a significant contribution to long-term erosion rates. Frequency distributions constructed from time series of measured erosion events are usually highly skewed, which has a significant impact on the simple arithmetic mean for the sample (Baffaut et al., 1998; Boardman and Favis-Mortlock, 1999). It must be noted that in some cases, a more statistically suitable measure of central tendency is the median value.

Spatial variability in landscape-scale, soil-erosion processes require discretization of landscape representation in georeferenced spatial information. These necessities have led to the coupling of modeled hydrological and erosion processes to GIS. GIS-based erosion models are used for simulating sediment and water transport at hillslope, watershed, or landscape scales, and predicting erosional risk. Simple erosion models have limited capacities to identify the precise location of sediment sources and sinks, and the patterns of their propagation.

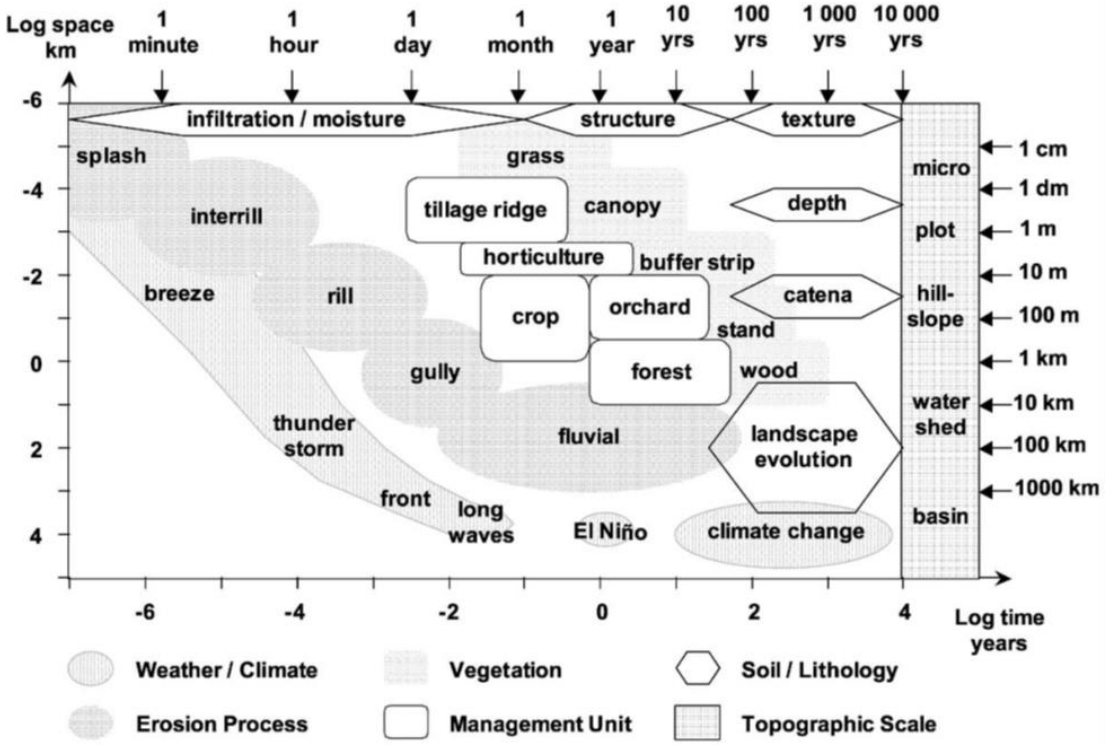

Fig. 1 Time and space extent of atmospheric, topographic, soil, and vegetation phenomenon important for dominant soil erosion processes. The management units indicate the extent of human interest and impact. (after Renschler and Harbor, 2002)

Shorter time scales are usually correlated with smaller spatial scales because finer time resolution requires more detailed modeling of the erosion process (Bull and Kirkby, 1997). At different scales, different groups of processes are dominant, and therefore the objective of the model changes with the spatial and temporal variation (Fig. 1).

5. A SHORT REVIEW OF SOIL EROSION MODELS

A wide range of soil erosion models has been developed in the past few decades, each differing in terms of physical processes simulated by the model, the model algorithms describing the processes, and the data dependence of the model (Bull and Kirkby, 1997).

The model complexity is determined by the details of the processes simulated, which can be translated not only in a great number of equations but also in the high number of input parameters (Merritt et al., 2007). Several factors should be taken into consideration when choosing the model: (i) dataset requirements of the model; (ii) fundamental assumptions of the model; (iii) model capabilities and susceptibilities; (iv) the components of the model; (v) user-friendliness of the model; (vi) the objectives of the model; (vii) the scales of the model outputs; (viii) hardware and software requirements of the model (Hajigholizadeh et al., 2018).

Soil erosion models are divided into three main categories: empirical or statistical, conceptual, and physical-based models. They can also be described as a hybrid between the 2 of those classes.

5.1 Empirical models

Empirical models are convenient as a first step in identifying soil erosion sources due to the limited data and parameter input. The most famous examples of empirical models include the Universal Soil Loss Equation (USLE) and its derivates RUSLE (Revised Universal Soil Loss Equation), as well as MUSLE (Modified Universal Soil Loss Equation). According to Smith (1999), empirical models are incredibly useful in many situations, given that they are, to no small extent, the only models that could run with little available data. In his opinion, their main limitations are: (a) are based

on statistical analysis and yield only approximate and probable outcome; (ii) are not practical for the prediction of soil loss on an event basis; (iii) estimate soil erosion on a single slope; (iv) does not represent the process of sedimentation; (v) are restricted to the sheet, and rill erosion; and (vi) soil losses and gains over neighboring areas are not considered. However, another limitation is its applicability to areas with different ecological conditions other than from which the data were used in their development. While criticisms are valid these limitations restrict the use of more complex models. Such models are generally based on the assumption of stationarity. This assumption limits the potential of empirical models to be event-responsive and to predict the effects of catchment change (Saavedra, 2005).

5.2 Conceptual models

Placed between empirical and physically based models, conceptual models aim by reflecting the physical processes governing the system by describing them with empirical relationships, e.g., Agricultural Non-Point Source (AGNPS) (Tesfahunegn, 2011). Conceptual models indicate the qualitative and quantitative effects of land-use changes, without requiring large amounts of input data (Merrritt et al. 2003). Factors such as rainfall and runoff for input and, sediment yield as output are used. These models have the inherent disadvantages of the empirical models and require relatively detailed data for calibration.

5.3 Physically based

Physically-based models are implemented in more complex situations, using mathematical equations dealing with the laws of conservation of energy and mass (Morgan, 2005) to provide an understanding of the fundamental sediment producing process and have the capability to access the spatial and temporal variations. Those models are generally the most accurate and flexible in input and output and are based on a comprehension of the physical processes that cause erosion.

Therefore, they apply to a wide range of ecological conditions (Lilly et al., 2009). Similarly, Ganasri and Ramesh (2016) agreed that physically based models are data-intensive, and the amount of data needed is not readily available and often challenging to parametrize.

Many different erosion and sediment -nutrient transport models are currently available. These models differ in complexity, the processes modeled, the scale to which they are applied, and assumptions on which they are based.

6. MODEL SELECTION

The reasonableness of the model and the availability of the data are the leading principles when selecting a model. In practice, the environmental data that are obtainable contain information to describe, only the dominant process active in a given system, which may be described effectively by conceptual processes (Young, 1998). Indeed conceptual models (semi- empirical) offer a compromise between the need to explicitly deal with the main physical processes and the limited data availability, and may, therefore, be appropriate in characterizing the distribution of erosion within the catchment (i.e., Van Rompaey et al. (2003a) and Vigiak et al. (2005) obtained acceptable results with a simple transport-limited erosion model whose main driving factor was topography).

For the present study tree distributed conceptual models (RUSLE - 3D, Revised Universal Soil Loss Equation-3D; USPED, Unit Stream Power – based Erosion Deposition; SPL, Stream Power Law) were selected based on a set of criteria of : (i) relatively low data demands, (ii) ease of use, (iii) easier parameter estimation, (iv) GIS integration and (v) potential for improvements (Table 1). The selected models allow the prediction of the location of erosion source and/or depositional areas, as well as the quantity of soil. They predict erosion rates on an annual basis, considering the spatial distribution of the hydrological and erosional model variables.

Table 1. Main characteristics of the selected models

Model	*RUSLE – 3D*	*USPED*	*SPL*
Temporal scale	- Event - Annual	- Event - Annual	- Event - Annual
Climatic data requirements	- R-factor - Event EI_{30}	- R-factor - Event EI_{30}	- Annual rainfall amount
Hydrological data requirements	- Rainfall - Upslope - Contributing area	-Runoff amount - Peak flow	- Runoff amount
Main drivers for soil erosion	- Rainfall erosivity - Slope	- Unit stream power	- Stream power
Catchment representation	- Raster based	- Raster based	- Raster based

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InSAR digital terrain models for mining areas based on Sentinel-1 imagery. A case study in Căliman area

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Abstract. Although not intended at first, SAR satellite technology has been used for digital terrain models (DTM) generation and displacement monitoring for the last 30 years starting with the launch of the first RADAR imaging satellite by the European Spatial Agency (ESA), ERS-1. Currently, there is a suite of satellites available for these applications, with ESA's Sentinel-1 being one of the most accessible and exploited by scientists due to its wide and free of costs availability. The C-band repeat-pass interferometer is considered unsuitable for DTM generation due to its acquisition geometry. In this study, a DTM based on Sentinel-1 imagery for the former sulphur quarry mine in Căliman Mountains is derived in order to demonstrate the potential of the dataset for time and cost effective monitoring of large areas.

Keywords: *InSAR; Digital terrain model, mining, Sentinel-1*

1. INTRODUCTION

The launch in 1978 of the first spaceborne imaging radar, SEASAT, by the National Aeronautics and Space Administration (NASA) showed for the first time the capability of Synthetic Aperture Radar (SAR) technology to capture reliable information about the Earth's surface physical properties, such as topography, morphology, dielectric properties, roughness and backscattering. The satellite SAR is an active system which operates within the microwave domain of the spectrum, being almost independent of meteorological conditions or illumination from external sources. Also, the side-looking geometry, the synthetic aperture and pulse compression technology increase achieved resolutions from tens of meters to a few meters.

Interferometric applications of SAR imaging data became popular with the launch of the ERS-1 satellite by the European Space Agency (ESA) in 1991, when various research groups investigated the method's potential with success (Bamler and Hartl, 1998, Klees and Massonnet, 1998, Ferretti et al., 2007, Smith., 2002, Hooper et al., 2004). Since then, the number of available SAR satellites increased rapidly, with the launch of Envisat, TerrasSAR, ALOS Palsar and Sentinel-1 satellites, today large datasets of SAR imagery offering a complete picture of the whole Earth's surface for the last 30 years. The applications based on SAR imagery are very diverse, such as digital terrain models generation, surface displacement monitoring, land classification, ice sheet monitoring, flood monitoring, etc (Cloude, 1997 Simons et al., 202, Stramondo et al., 2005, Rott, 2009, Pepe and Calo, 2017, Kussul, 2011). The most popular bands for lands surface applications are the X band ($\lambda \approx 3$ cm), C band ($\lambda \approx 5.6$ cm) and L band ($\lambda \approx 24$ cm).

Since the launch of Sentinel-1A satellite in April 2014, the first in ESA's Copernicus programme, the opportunities for accessing SAR imagery data increased substantially. Sentinel-1B satellite was launched in 2016, increasing the temporal resolution of the mission from 11 days to 5 days, which is unprecedented for SAR imagery. In terms of spatial resolution, Sentinel-1 can assure values of

up to 5 m. Due to its wide free of cost availability, Sentinel-1 imagery was used in a large number of studies that focus mainly on displacement monitoring (Fiaschi et al., 2017, Huang et al., 2017, Raspini, 2018, Gheorghe et al., 2020). Due to its small baseline, the mission is not considered the best option for InSAR DEM generation. However, the current study aims to demonstrate that with the right selection of image pairs, a qualitative DEM can be obtained using Sentinel-1 C band imagery. In this purpose, the paper describes the general principles of InSAR and the methodology applied to derive a DEM of a mountainous area in Romania.

2. STUDY AREA

The study area is a former sulphur mining quarry of approximately 5 km^2 located in Căliman Mountains, which are found in the central-northern part of Romania. Pietrosul Căliman Peak is 2100 m high, which makes it the highest out of the mountainous group it belongs to: the Central Group of Eastern Carpathians. The mine used to be an industrial area of high importance in Romania, which was operational between 1969 and 1997. The quarry can be still found today on the northern slope of the Căliman massif, inside the mountain caldera Fig. 1). Since the cessation of activity, the study area continued to be affected by landslides, erosion and land failure, presenting also solid waste piled in the form of huge overburden dumps (Fig. 2). However, very few monitoring studies have been carried out in the area, especially due to the limited accessibility of the mining quarry, as well as the high costs of terrestrial surveying campaigns.

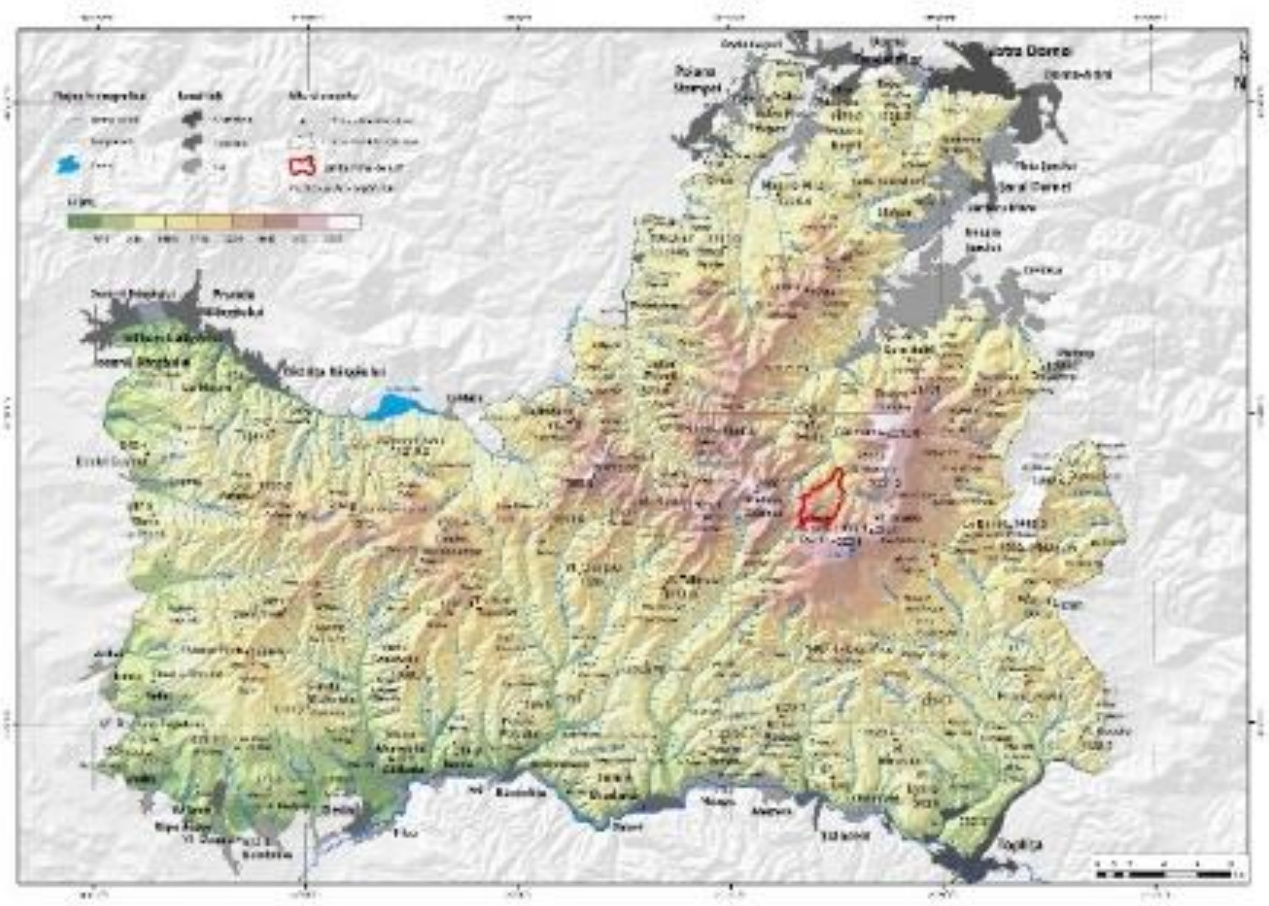

Figure 1 Location of the mine in the Căliman Mountain group

Figure 2 Satellite image of the actual state of the study area. The overburden dumps due to solid waste are marked in red.

3. METHODOLOGY

Terrain reconstruction with SAR images is similar to conventional mapping using optical imagery. InSAR determines stereo parallaxes with an accuracy up to a fraction of a wavelength using the phase of the radar signal (Bamler and Hartl, 1998). The phase difference between two complex SAR images acquired for the same area from different points of view of the sensor is computed for each pixel. Sentinel-1 can be used as a repeat-pass interferometer based on images taken at different times, separated by days. Most of the single-pass spaceborne SAR were not considered optimal for InSAR applications because they were not initially designed with this application in mind (Bamler, 2003). Baselines (the spatial distance between two orbits) are especially important for InSAR applications (Fattahi and Amelung, 2013). Ideal baselines have to be long enough for the mapped area to be imagined from two different geometries but also not to exceed the optimal length for maintaining a good coherence between the images. A critical baseline ranges from 150 m up to 1000 m. Sentinel-1 orbits have short baselines, which are usually not suitable for DEM generation. For the current study, the selection of the image pair with a suitable baseline for DEM generation was the most challenging aspect.

The images selected for DEM geration are Single Looked Complex (SLC), acquired in Interferometric Wideswath (IW) mode products, with a perpendicular baseline of 124 meters. They were acquired 21 days apart by the Sentinel-1A satellite, on 8th of J\uly and 1st of August respectively on path 131, frame 149 (Fig. 3).

Figure 3 Extent of selected Sentinel-1 imagery

The processing chain for DTM extraction was implemented in the SNAP open source software provided by ESA. Sentinel-1 images are initially divided in multiple sub-swaths and bursts (Fig. 4).

The *TOPSAR-Split* operator, which is the first in InSAR processing chains, provides a convenient way of splitting each sub-swath and selected bursts into separate products.

The next step was *orbit correction*, which has the goal of removing orbital errors caused by inaccurate orbit state vectors provided in the metadata of a SAR product. The orbital correction necessitated precise orbit files which are available up to 14 days after the generation of the SLC product.

The *Back-geocoding* step refers to a DEM assisted coregistration. For this step, the SRTM 3Sec DEM was downloaded automatically and used as reference.

The *Enhanced Spectral Diversity* estimates a constant range offset for the whole sub-swath of the split image based on incoherent cross-correlation. The estimation is done individually for each burst, being averaged afterwards in order to derive a constant range offset available for the whole sub-swath.

The intermediary product was then exported for phase unwrapping in SNAPHU. Prior to the unwrapping step, a Goldstein filter was applied in order to reduce noise in the resulted interferogram. After filtering, the images were debursted, meaning that the bursts were concatenated and the sub-swaths merged to form a single-part image.

The *Interferogram* formation operator computed the complex interferogram with the subtraction of the flat-earth phase, since the orbits for the interferometric pairt were known. The flat-earth phase is estimated from the orbital information and subtracted from the complex interferogram. The reference system of the surface is the same as the satellite orbits reference system, which is WGS84. The generated interferogram is imported back to SNAP for further processing

The next step is Phase to Elevation, which translates phase differences shown in the complex interferogram to corresponding elevation values of topography.

In the end, a *Terrain correction* is applied in order to compensate for the tilt of the satellite sensor in relation to topographical variations of a scene, which results in distorted distances in the SAR images.

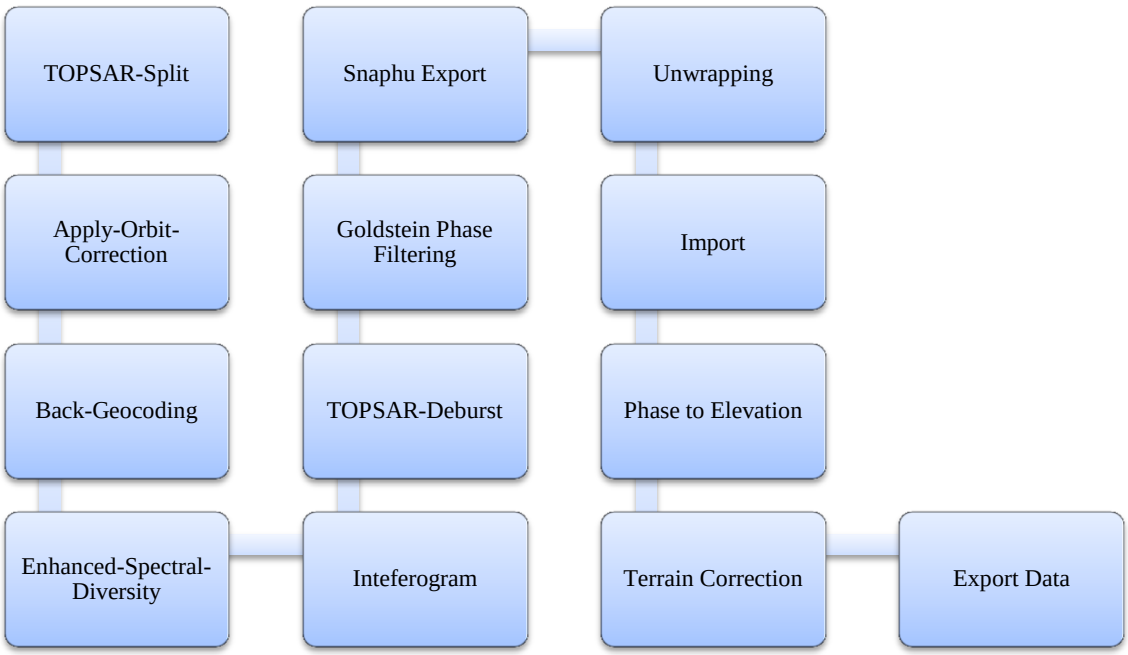

Figure 4 Processing chain for DEM generation in SNAP

4. RESULTS

The DTM extracted from satellite data has a resolution of 2.7x22m to 3.5x22m in range and azimuth respectively. The model was obtained in the same reference system as the satellite images, WGS 84 (EPSG 4326), Universal Transverse Mercator projection.

In order to assess the vertical accuracy of the DTM obtained from satellite imagery, it was projected in the Stereographic projection 1970, EPSG 3844 and compared to an older DTM derived from in-situ topography measurements conducted in the study area in 1980. The obtained DTM shows a 5 m vertical accuracy (Fig. 5).

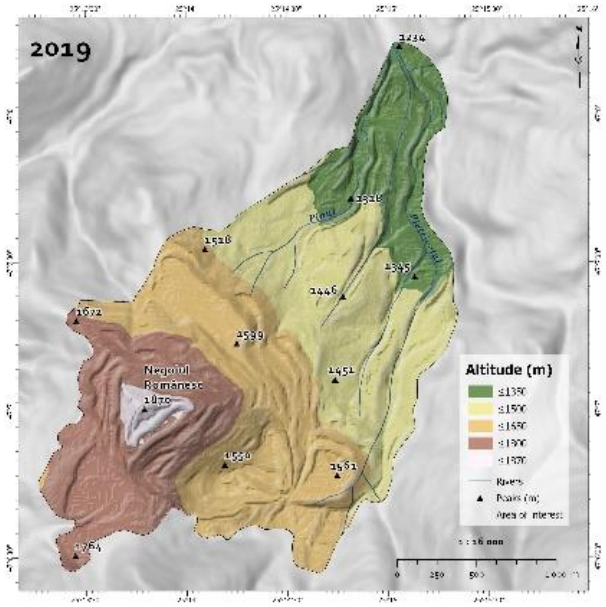

Figure 5 Digital Terrain Model of the Sulphur mining area extracted from Sentinel-1 imagery

5. CONCLUSION

Although a method more recent than optical stereo mapping InSAR has become more and more adopted for real life monitoring applications. DTMs obtained from SAR interferometers provide high resolution for local scales, while the SRTM mission was able to map the entire Earth within 11 days. The current paper explored the capability of Sentinel-1 imagery to provide an accurate DTM of a remote mining area found in the mountains. The obtained results show that a proper selection of acquisition geometry can lead to quality products. A great advantage of being able to use the Sentinel-1 imagery for any type of applications is given by the great volume of data available for all Earth.

The methodology employed in this study can be used for processing DTMs from a higher number of images for improving accuracy of the results that can change the approach for long-term monitoring.

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Bucharest Drivers' Perception of Navigation Apps and their Impact on Road Traffic

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Abstract. Bucharest is one of the most affected cities in the world in terms of road traffic congestion and under these conditions, drivers are constantly looking for new strategies to help them cope with daily traffic. They are increasingly relying on more on navigation applications installed in their smartphones with GPS capabilities. This research aims to investigate drivers' perception of the way they use navigation applications and their purpose, especially Waze, their perception of the impact of these applications on traffic and the city or even on socialization (socialization through the application or the socializing effects of the application itself). The study conducted in 2018 reveals the positive perception of the impact that the application has and highlights its new affordance, drivers using it as a socialization tool, a utility that was not initially intended.

Keywords: *navigation applications, mobility, traffic congestions, road traffic*

1. INTRODUCTION

Bucharest is one of the most affected cities in the world in terms of road traffic congestion according to the TomTom Traffic Index report. Traffic congestion is not just a problem during peak hours (data collected in 2014 show that this indicator becomes 84% on Tuesday mornings and 87% on Friday evenings) but almost all day long. In addition, a specific characteristic is that the congestion on secondary roads is much higher than congestion on main roads. According to the evaluation made in the Sustainable Urban Mobility Plan 2016 - 2030, one of the most important causes is the increase of road traffic in a network that does not keep pace, in the Bucharest-Ilfov region even more than in most of the country. In theoretical models, most traffic should be on express roads and arterial streets, the golden rule being 30% of roads take over 70% of traffic but in Bucharest, the main roads have certain impediments - parking, public transport - that prevent them from functioning as important arteries.

Under these conditions, traffic participants are constantly looking for new navigation methods and tools to help them cope with daily traffic, so drivers have become increasingly reliant on navigation applications installed on smartphones with GPS capabilities.

A research on habits and attitudes in road traffic in Romania shows that, nationally, at the end of 2018, 4 out of 5 traffic participants said they used navigation applications to deal with road traffic.

This research aims to investigate the drivers' perception of the purpose and way they use navigation applications, especially Waze, their perception of the impact of these applications on traffic and the city or even on socialization (socialization through the application or the socializing effects of the application itself).

2. A BRIEF HISTORY OF NAVIGATION APPLICATIONS

The rapid development of integrated technology in the automotive industry brings significant changes in the experience of driving a vehicle. Thrift (2004) states that this experience has already entered our "*technological unconscious*". The development of transport systems includes the introduction of

autonomous vehicles, which will soon render independent navigation instruments obsolete and they will be "*completely absorbed*" in the car (Fisher, 2013)

Currently, the number of navigation applications is very high, this being due, on the one hand, to the development of infrastructure, and on the other hand to technological progress, especially in terms of smartphones. If 8 years ago, using an application like Google Maps on mobile phones was a challenge (processors were too slow, satellite connection was very weak), now most of these devices are able to provide a very good user experience.

This technological progress, but also the growing need of people to navigate in crowded cities have led to the emergence of a highly competitive market in the field of these applications. In addition to Google Maps (still the most used application of its kind), many others have appeared: Waze, Apple Maps, MapQuest etc, each offering specific features. Google Maps, for example, is based on a map created by its own means, while the Waze map is built on the information sent by users, so they are at the same time the creators and users of "real-time maps".

Some of the defining aspects of this current period include big data - collecting large volumes of data (either actively through crowdsourcing platforms on which we contribute voluntarily or passively, through our acceptance to let our activity monitored online and offline) and modeling processes based on the analysis of these data, the impact of online social networks on society - social media is being used in ways that shape politics, business, world culture, education, careers, innovation, and more but also to change processes through the growing presence of artificial intelligence in our intimate and everyday landscape (email services, navigation, etc.).

The concept of crowdsourced cartography, as defined by M. Dodge and R. Kitchin (2012), refers to the way in which the community is involved in the development and modeling of digital structures, voluntarily providing the information needed to manage various activities.

Crowdsourcing is also one of the principles on which the Waze application was developed. Used by drivers that contribute with real-time data, thus gaining superior accuracy to other applications, but also a much better representation of current traffic. But why are people willing to contribute without explicitly receiving something in return? The explanation offered by the above mentioned authors is that the application provides a platform that allows people to interact, communicate with each other and especially contribute collectively to achieve a *common goal* – an easier navigation through the jammed traffic of the crowded cities.

In the same article published in 2012, Dodge and Kitchin introduce the term "*Prosumption*", which is closely related to "crowdsourcing". *Prosumption* represents the quality of a person being, at the same time, both producer and user of the product.

Prosumption describes a special relationship that is created between the "provider" and the "*prosumer*": the latter does not receive any reward for the effort (other than intrinsic satisfaction, probably), and the provider does not have to hire (therefore pay) workforce, and even receives very valuable information from the social reality of users.

Lakhani and Boudreau (2013) proposed o model for the crowdsource approach (Figure 1)

3. ABOUT SOCIAL NAVIGATION

Hind and Gekker (2014) mention the developers of the Waze platform in the study *"Outsmarting Traffic, Together: Driving as Social Navigation"* as the ones who invented the term "*social navigation*" in the industry, defined by the development of "*digital mapping platforms designed to foster automotive sociality."*

They consider two aspects – one related to "playful" conceptualizations and refer to touch-screen satellite navigation platforms that include "gaming" as an inherent component of social relations with an example of the application of game-type mechanisms (rankings, avatars, bonus systems) and a second, which is more related to traffic driving policies and aimed at how drivers interact with digital interfaces.

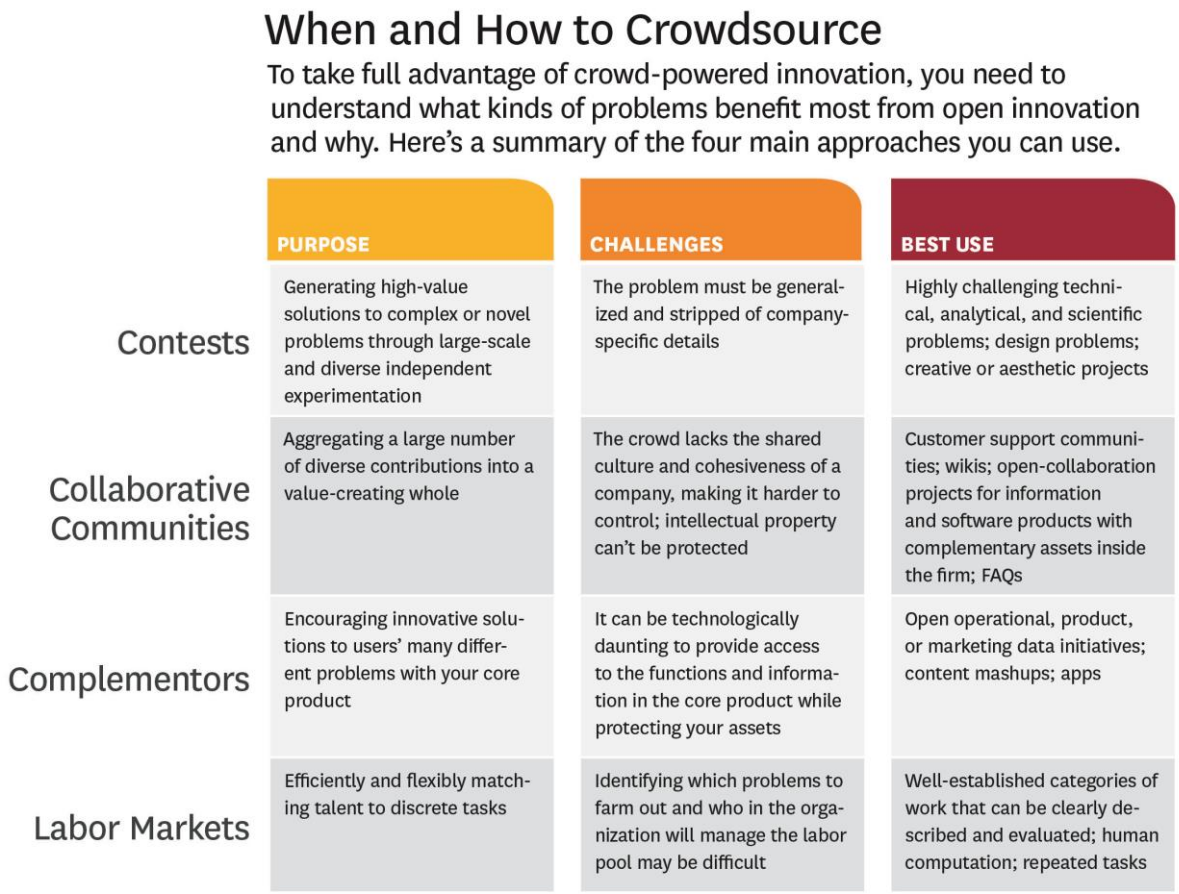

Fig. 1 Crowdsource approach model

In the same article, Sam Hind and Alex Gekker introduce another term - "*casual politicking*", which refers to the way in which the acquisition of practices specific to ordinary driving led to the emergence of the necessary conditions for the development of a special form of social policy, represented by in which each person can contribute, through digital, to the modeling of virtual reality.

To these two aspects, I add a third, *prosociality* under stress, and this is due to the fact that in the case of this study it is a specific local element - traffic in Bucharest is associated with a high level of stress for drivers. Stress, although it can be seen as a challenge, as a maladaptive element, is a psychological mechanism that plays a key role in ensuring the survival of the body. According to the perspective presented in article *The Social Dimension of Stress Reactivity* (von Dawans et al., 2012), stress is the factor that determines the body to allocate the necessary resources to cope with a dangerous situation (fight or flight, for example).

In the same article, the authors present the concept of "stress" as a factor that facilitates or leads to the emergence of prosocial behavior and demonstrated this experimentally: they selected several students from the University of Zurich, whom they subjected, in laboratory conditions, to stressful situations and then by applying personality tests they were able to highlight aspects related to prosocial behavior. Following the experiment, a strong positive correlation was found between the presence of stress and *prosociality* (measured, in this research, by trust, "sharing behavior" and social interaction).

A study conducted in the US, "*The Popularity of Google Maps: Trends in Navigation Apps in 2018*" on a sample of 511 users who use at least 3 different applications daily reveals that over three quarters (77%) of smartphone owners use navigation applications regularly – a result confirmed by a similar research in Romania. The same study indicates Google Maps as the most popular navigation application, followed by Waze.

Most people use such applications because they offer better itineraries, so directing the preference to Waze is logical, they believe that Google Maps provides the best directions due to the quality of Google maps, collected through the Street View program and aerial images obtained by satellite.

A balanced approach implies that we will evaluate both the advantages and disadvantages of GPS navigation applications, considering that these can have negative consequences on the way drivers navigate, mainly due to a "blind" dependence that can endanger them.

Although Google Maps is currently the most used navigation application, not only, (Figure 3), only on the Waze application because we explore not only the navigation features but also aspects related to socialization.

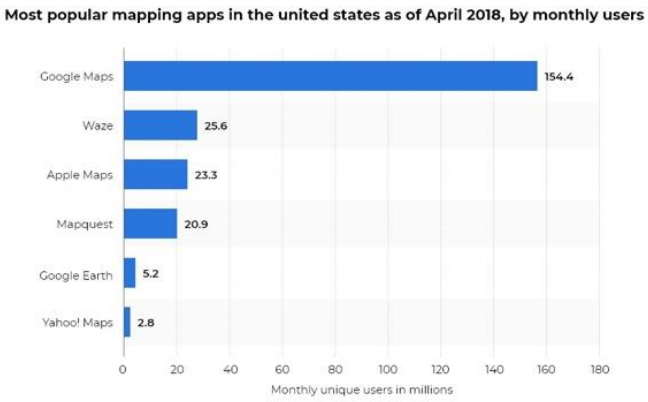

Fig. 3 Navigation apps usage in US, 2018

4. ABOUT WAZE AND THE COMMUNITY

Waze is a free, real-time navigation application, whose map was created by its users from scratch. In 2011, Waze had 10 million users, currently it has reached 130 million, a growth rate of 3-4 million per month and it is quite complicated to make a clear distinction between those who produce the map, those who edit it and those who use it. This large community has turned the application into a very accurate map, allowing users to alert each other about traffic events. Although initially the application was designed only for those who commute from home to work, Waze has become more than that, incorporating current trips to unknown destinations.

Waze calculates routes based on real-time traffic, but also based on the history of travel routes in the application. Routes are calculated by a server, the application itself being more of an interface.

As mentioned earlier, in the paragraph dedicated to the concept of Politicking in the Waze application, each user has political power. Anyone can use the options provided by the application, to bring virtual reality as close as possible to the current one and to constantly add relevant content. In a way, the accuracy of the application is the common goal of all users, so each of them is motivated to contribute the right information.

The idea of the "social navigation" application encourages detailed reporting of problems with the map, reporting under anonymity, but also relying on effective communication between users and publishers. Thus, Waze undertakes to correct the mistakes or inaccuracies of the addresses or to eliminate duplicates, all operations being performed through the reciprocity of the Waze database - Google Maps.

Waze has transformed from a navigation tool into a platform that connects people around the world and contributes to the same goal, a greater good – making transportation better for everyone. Drivers are connected to each other and the app forms local communities to improve the quality of daily commutes. It is extremely important to note that the application is still powered by data maintained and distributed in a voluntary system of the user community.

Users can use the app passively (drivers who only drive with the app open) but also actively, either by sharing their traffic experience by reporting accidents, radars or other hazards, or by taking on the role of Waze editor.

The application offers the possibility to set destinations such as work, home or other frequently frequented locations, which can plan routes so that the user receives reminders of the time when he has to leave home in order to reach the destination on time.

Waze can be synchronized with the calendar and events on Facebook, thus receiving directions to navigate these events directly from the application or routes can be sent, preferably, to contacts in the friends list, with the option to follow the route live.

To encourage users to contribute as actively as possible, Waze has introduced a gamification

module, specific to the world of gaming, in order to encourage the most active participation of users.

Waze started as an application that also provided a "game" component in addition to the functional one. The purpose of these components is different, they are for example either strategies to increase the engagement of users through different elements: the system of "conquering" the map and finding rewards offered by developers through which users can "evolve". The avatars in the application, improving their characteristics, as in an online game or strategies to complete as large as possible the map - the concept of "conquering" by moving on the map was supported and promoted by Waze by placing rewards in unexplored locations.

The scoring system that builds the rankings within the application offers a multitude of methods by which different actions can be capitalized: covering a large number of kilometers, signaling traffic situations, confirming them etc.

One of the essential dimensions of the application, which has remained constant, is that of the community. For example, joining a team can accessorize your avatar with a specific symbol or certain functions in the application, for example becoming an editor provides you with access to a certain category of accessories to personify the user.

Another option of the Waze application (perhaps the most relevant for this study) is the "chat" option. It gives users the opportunity to communicate, in a simple way.

5. WAZE IN ROMANIA

As everywhere in the world, the Waze Romania map was created by users, volunteer editors, from scratch and is managed by them. We do not have official data related to the number of users but we have an estimate of over 4 million users in 2018 and the "Waze Romania Community" (https://www.facebook.com/groups/WazeRomania) is a Facebook group that brings together over 21,000 users and map editors. In the online environment, information is also available on www.waze.ro and the Facebook pages of Waze Romania (www.facebook.com/WazeRomania), Waze Info Trafic Romania, Waze Trafic Bucharest.

6. ABOUT THE IMPACT OF WAZE

Although Waze is not the most used navigation application (Google Maps being more used), it could be said that it has a strong influence on traffic. Being an application that works based on real-time feedback from users, Waze suggests detours, less crowded. The problem is that, often, the observance of these routes involves the use of secondary streets, adjacent to the main boulevards, and from here can arise the following problem: Waze users end up blocking the streets between apartment blocks, causing real inconvenience to residents and changing the traffic routines of a large number of people. In a way, it would seem that Waze is creating traffic where there wasn't any and changing some ecosystems.

The article "*The Perfect Selfishness of Mapping Apps*", written by Alexis Madrigal in 2018, highlights the idea that using applications like Waze is a selfish act, as this leads to artificially disrupting quiet areas.

In other words, people strictly follow their individual interest (that of getting to their destination as soon as possible), without caring about how it affects others.

This research does not aim to analyze the impact of the Waze application on those who live on the streets adjacent to the main boulevards, but we can say that, empirically, this effect exists and is quite significant in Bucharest. From the increase in the number of road accidents, to the change of traffic signs on the side streets (two-way streets became one-way streets, due to the fact that cars parked in those areas could get out of the parking lot only with great difficulty, in the context of rush hour traffic jams), it is clear that as a result of the massive use of the Waze application by drivers, there are significant changes in road traffic flows, and in the practices and routines of city dwellers.

7. WAZE AND THE TRAFFIC IN BUCHAREST

The poor infrastructure, as well as the increasing number of cars in Romania (and not only), lead to traffic congestions, both in big cities and on extra-urban roads, it is obvious that traffic has become an important stressor. In Bucharest, for example, people make their daily schedule, choose their job, home, etc., depending on road traffic.

As most Bucharest inhabitants (and not only) spend a lot of time stuck in traffic and Waze is (perhaps) the most used navigation application, we believe that it could have a fairly significant impact on the way social relations are conducted.

The application is built as an interactive map (interaction between man and map), relying heavily on user reports "many to one", but it was not designed with the intention of a social network (interaction between people). This statement is justified by the fact that the application provides users with numerous options for reporting traffic events, but for communication between users, a fairly rudimentary "chat" is available, compared to applications whose purpose has been since beginning, that of creating social networks and communities (even if the reports sent by users can also be defined as forms of interaction, they are implicit, not explicit - they are oriented towards a "greater good", not towards particular individuals.) Given the above, the study aims to find out whether Waze, despite technological limitations, can be a tool through which social relationships can be created, and the premise from which we start is that people will use the application, not only using the functions for which it was designed, but also to create social cohesion and to overcome stressful (traffic) situations more easily by using the chat function.

The aim of this study is to investigate how traffic participants use Waze, their perception of the impact these applications have on traffic and the city or even on socialization (application socialization or the socialization effects of the application itself).

The research methodology included a quantitative research conducted online during January 18-25, 2018, data collected by completing a questionnaire with 12 questions that we distributed on Facebook on personal profiles and in various groups.

As of January 24, we had already collected over 500 responses and then we decided to add another dimension to our research. We added a more specific question to the questionnaire, intended for map editors and distributed it to the Waze Romania Community group, collecting data for 24 hours. During this time, we received over 600 new answers. When interpreting the data, we also tried to identify the differences between the responses of a general audience, Waze users, and a much more involved group.

8. SAMPLE STRUCTURE

A first observation is related to the composition of the study sample, although the distribution of the questionnaire was not made on a previously selected sample on the basis of representativeness, it was a relevant and balanced composition. The general gender distribution is correlated proportionally with the way in which driving licenses are distributed in Romania, respectively 30% women and 70% men, including the distribution within the sample from the Waze group - 9% women and 91% men who reflect correctly the studied group, the members being predominantly male.

Over 70% of those who answered the questionnaire are between the ages of 26 and 45, and 68% of those in the Waze group are between the ages of 18 and 35.

In both groups, the majority of respondents are amateur drivers (91%) and spend between 30 minutes and 2 hours in traffic (76%), and there is no difference between the two groups.

9. WAZE USAGE

The frequency distribution with which the two groups use the Waze application is similar, most of them being in the active consumption area as shown in Figure 4.

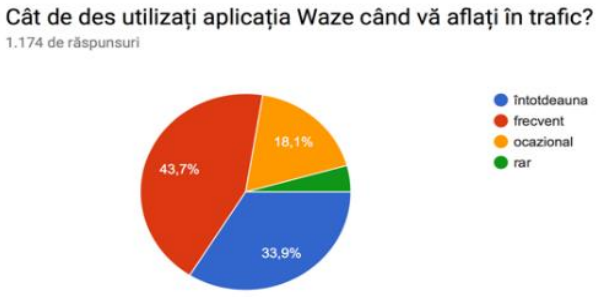

Fig. 4 How often do you use Waze while driving?

As for the level of confidence given, it is extremely high throughout the sample. The proportion

of active users is obviously very high in the Waze group (83%) and quite high in the case of the second group, 60%, with an overall average of 72%.

Regarding the way they actively use Waze, 75% are contributors and use it to signal the situations encountered in traffic in the application.

As for the perception of the impact of the application on the majority driving experience related to utility in navigating the city, followed by exploring the city (answers to the question "*What is the impact that you think Waze has on your personal driving experience?*") – most participants in both groups responded that Waze helps them reach their destination quickly and safely (55% for the Waze Group (GW) and 48% for the general public (PG)), while 32% of GW and 27% of PG consider that the app helps them discover the city, showing them less frequented routes. The third option selected by the respondents was "*it gives me the option to personally contribute to safer traffic*". From the answers provided by the study participants we deduce that the Waze application is used due to the perception that it is *efficient* (indicates the route), is *reactive* (changes the route according to several parameters related to traffic) and is *interactive* (gives them the opportunity to actively involved in order to obtain a "safer" traffic).

Respondents believe that the most important impact that Waze has on urban traffic is to streamline traffic across the city, while very few believe that the application could have a detrimental effect on adjacent streets. This result seems to confirm the hypothesis set out in the article *"The Perfect Selfishness of Mapping Apps"*, according to which users of these applications tend to ignore the fact that they could cause major discomfort to other people in order to achieve a personal goal.

We also introduced a social dimension to the study and explored how users interact. Most of the participants in the study do not interact with other users of the application, but 7% of them answered that they use the "chat" option to participate in public discussions or to get involved in games initiated by others and 5.7% use this option to exchange messages with friends.

Most people who use "chat" do so when they are stuck in traffic (30%) or when they have a technical problem (11%). The perception of the majority is that the application helps its users to reach their destination faster and safer (over 80% of participants).

The side effects of using the application in traffic are ignored, 85% of respondents said that Waze helps streamline traffic throughout the city, while only 22% believe that the effect of using the application is to crowd the streets adjacent to major boulevards.

10. SOCIALIZATION

When asked, "*What is the purpose of using the Waze app?*", most of the participants in this study answered that they use the app for the purpose for which it was created: traffic navigation. Just over 2% of respondents said they use the app to socialize with other people.

Regarding the use of the application (passive, only as a consumer of information and active, as an active provider of traffic data that includes situations, road conditions, etc.), most participants responded that they use the Waze application actively, contributing to reports or alerts about various road events, most of them use "chat" to send messages to other users in connection with traffic situations, and 7% use this option to get involved in games (such as word games) or in public discussions, while 5.7% use it to chat with friends, see Figure 5 for a chat example.

Up to this point, it can be said that the Waze application is not mainly used for direct interaction with other traffic participants, but, when asked about the context in which participants use "chat", most have chosen the option of answer "when I'm stuck in traffic."

Fig. 5 Waze application screenshot – conversation

From this information, we can deduce that, even if the application is not currently used explicitly for socialization purposes, by offering the option of a direct communication option between neighboring traffic participants, it is a fertile ground for the development of interpersonal interactions. These interactions do not occur in free-flowing traffic conditions, but when there are traffic jams.

One explanation could be that people tend to affiliate with those in a similar situation, thus alleviating some of the accumulated frustration. This hypothesis correlates with the theory stated in the introductory part, according to which, in stressful situations, people tend to manifest a prosocial behavior. In the case of Waze, this behavior could be represented by the use of an auxiliary feature of the application ("chat") for communication purposes. It is obvious that, in the conditions of blocked traffic, the role of a navigation application is non-existent, especially when it comes to long, extra-urban roads, but nevertheless, people remain connected to the application and initiate various forms of interaction, such as word games, as shown in Figure 6.

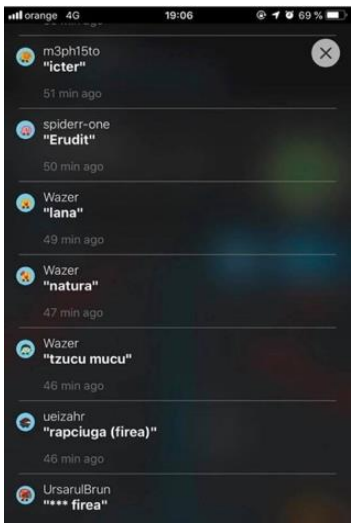

Fig. 6 Waze application screenshot - wordgame

Why not use other social networks, such as Facebook, when stuck in traffic? Probably one of the answers would be: Facebook does not meet, in these conditions, the need for affiliation. By using the Waze app, people only interact directly with those who are stuck in the same stretch of traffic (e.g. on highways, for example), and share the same feelings of frustration generated by a situation to which they are all connected. In this situation, the differences in status disappear and each person becomes just a simple participant in traffic and communication and social relations are much easier to establish, because other aspects related to age, profession, social class, disappear.

In conclusion, we can say that, although Waze is basically a navigation application, when the context demands it turns into a communication platform for drivers, a potential future social network.

11. CONCLUSIONS

Waze application is used mostly as a navigation tool, actively contributing with information and perceived as a useful tool in streamlining traffic throughout the city, disregarding the harmful effects on side streets adjacent to major boulevards. It is popular due to the perception that it is efficient and dynamic through route optimizations and interactive because it offers users the opportunity to get actively involved in order to obtain a "safer" traffic.

Regarding the psychological component, stressful situations can trigger prosocial behavior, but what could be the link between trafficking, Waze and pro-social behavior? Is this the new affordance of this navigation application? Using the chat option of the application can support this hypothesis, namely that Waze, despite technological limitations, can be a tool through which social relationships can be created.

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P. Krugman's Core-Periphery Model. Case Study: The Tourist Demand on the Romanian Seaside

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Abstract. Krugman's model is a new approach for Romania, even more applied to the Black Sea seaside. The tourist demand in such a way reveals the relations not only economic, but also of another nature between the core and the periphery. The data clearly show that this model is a forceful one, applicable not only to the Romanian seaside, but also to the region, country or continent, and its study can reveal very interesting conclusions: the influence of the core on the periphery, how the North and the South interact in the chosen model and how seasonality affects seaside tourism.

Keywords: *Krugman, core-periphery, tourist demand, seaside, seasonality*

1. INTRODUCTION

The tourist market, as a place of confrontation of supply and demand and as the main source of information, is a reference element of the tourist activity, sensitive to any fluctuation at micro and macro-economic level.

The analysis of the indicators resulting from the analysis of the complexity of the service providers and of the typology of consumers at public and private level can show the development or regression of the tourist market, respectively the efficiency of the growth efforts and consumer satisfaction.

The development of tourism must be carried out in such a way as to contribute to the improvement of the quality of life in a responsible manner on the part of all those involved in the tourism industry, both in the public and private sectors. They must combine the inherent disadvantages with the advantages, some of them unique in the world or, from another perspective, the maximum satisfaction obtained by the tourist by buying goods and services at the desired price.

The research of the tourism industry is not new, many authors having tried to develop, in a useful manner, a model of it. In order to have an objective study, the interaction of several study areas is required, more specifically a PESTEL research over approximately 55 years (1965-2018). However, this article will show a new facet of the Romanian tourism industry in terms of tourism demand, approached in a new way based on a method developed by Paul Krugman (1991).

To this model is added the seasonality of Romanian tourism, considering that it operates only 3 months in the summer season, respectively 2 months in the off-season, which requires a special research of this feature.

The study is limited to research on the Romanian seaside and tourism in this segment, showing some of the current problems, being important both for public administration and for those in the private industry. Krugman's model is not infallible, but it is observable throughout the research period, and seasonality as a specific feature of coastal tourism, is likely to bring additional data that can lead to a better understanding of the problem studied.

The data used comes from two sources:

- *public ones*, such as those of the National Institute of Statistics and the Ministry of Tourism;
- *private ones*, collected from the territory along the maritime coast in season and off-season in 2017, respectively from the internet, and based on a survey focusing on consumer theory. The survey consists of two parts: the situation in 2017 and a comparison with the period 1965-1989.

2. KRUGMAN'S CORE-PERIPHERY MODEL

In the current economic context, the core-periphery effect is more visible than ever, therefore it is necessary to analyze its effects on Romanian tourism, especially in order to counteract the too strong development of rich centers and to help the periphery benefit from the same advantages as the center.

The monopolistic concentration of the center leads to economic impositions to the detriment of the peripheral regions and, through this, the partial development of the latter. Fujita, Krugman and Venebles (2001) show that, at a certain historical moment, this effect has the role of unbalancing economies, respectively, depending on the evolution of GDP, of strengthening the economy.

This model shows that geography and trade are likely to influence the growth and decline of a region, as Krugman showed in his fundamental paper: *to develop a simple model that shows how a country can endogenously become differentiated into an industrialized "core" and an agricultural "periphery".*

The core-periphery model consists in the development of a strong center, with clear advantages over the periphery, which is impoverished in terms of industry, services and population.

While the center is enriched by various investments that attract more money, but also salary increases, higher rents, more staff, in the periphery there is an acute lack of investment, low wages, low rents that often do not cover the ordinary expenses of a household.

One of the most important economic indicators, mentioned by Krugman himself, is the migration of the population from the periphery to the center. Throughout history, this phenomenon can be observed, obviously not only in a single region or a country, but also at the continental level.

In our representation below, we distinguish this Krugman model on the Romanian coast: Constanța Municipality as the main nucleus for the northern part of the coast and Mangalia as the secondary nucleus for the southern part of the coast.

A special component of the market, respectively of the tourist services, is represented by the set of sale-purchase documents whose legal object is represented by the tourist products from a certain space and certain economic relations, forming the tourist market. The two main components - demand and supply – complement each other, being dependent on each other: demand is the result of supply, and supply is a cumulation and a synthesis of information provided by tourists (Charles and Ritchie, 2011).

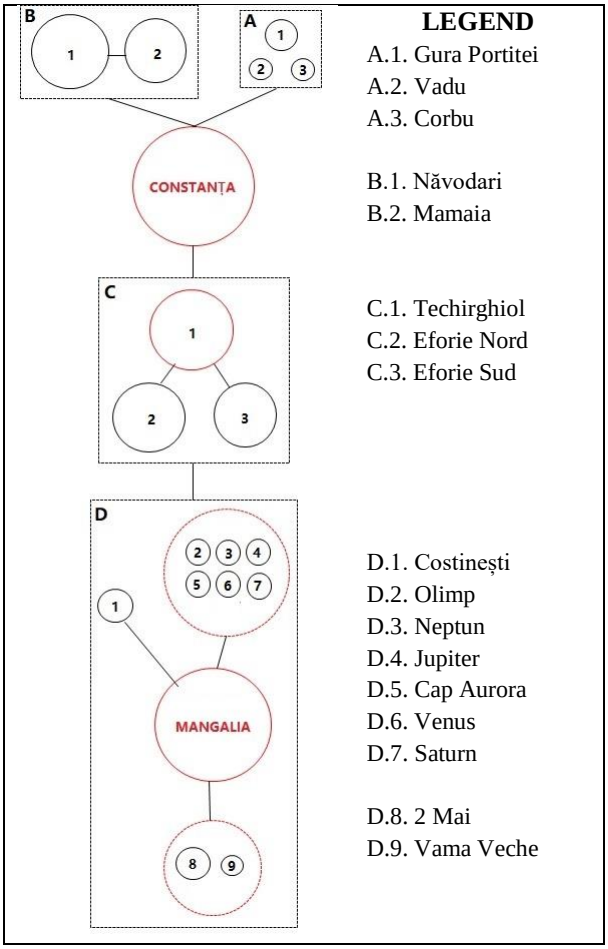

Figure 1 The Krugman model applied to the Romanian coast. Source: Author

Naturally, in relation to supply, the decision of tourist consumption occurs, the connection is made only at the beginning of consumption and the place of supply is always the same as that of consumption: tourist demand therefore consists in all requirements manifested or not yet manifested for the approximation of tourist products, with tourist consumption being its result (Goeldner and Ritchie, 2011).

The peculiarities of the tourist demand are:

- *it is elastic*, being permanently subject to the fluctuation of economic, social, demographic, psychological factors, etc.;
- *high degree of heterogeneity and complexity*, the study requiring the segmentation of the sample according to different criteria (age, occupation, consumption habits, etc.);

- *high degree of mobility*, mainly caused by supply rigidity;

- *strong seasonal character*, the reason being the dependence of the tourist circulation on certain factors, respectively on the unequal distribution and on the non-storable character of the tourist offer (Lickorish and Jenkins, 2000).

The modeling of the Romanian seaside according to Krugman's model incites empirical speculation; however, together with the official statistical data provided by the National Institute of Statistics and the Ministry of Tourism (official data that, incidentally, do not correspond to each other!) we can make a somewhat accurate estimate of situation.

3. THE MAIN TOURISM DEMAND CHARACTERISTICS ON THE ROMANIAN SEASIDE

In the southeastern part of Romania, the most visited destination is Constanta County, the localities along the Black Sea seaside being the most attractive for tourists. Excluding the spa resort Techirghiol from the Peripheral Area no. 3 in the North, 97.60% of tourists choose these localities, spending the night there in a similar percentage: 96.70%.

3.1 Northern Core-Periphery Area

In the analysis of the present situation we will take into account that in the Peripheral Area no. 1 from the North (which contains the localities from the wild area Corbu and Vadu and the semi-wild Gura Portitei), although having a few registered accommodation structures, most tourists spend the night in tents, motorhomes, personal cars, residents' houses (located about 5 km from the beach) or directly on the beach, therefore we will not know the actual number of arrivals in this region.

a) Tourist Arrivals

From an administrative-territorial point of view, Gura Portitei resort is located in Tulcea County. In terms of the statistical data, it can be seen that in 2009 was a crash for the Romanian economy: while 3,213 tourists were officially reported in 2007, in 2008 - 9,824 tourists, in 2009 the number decreased to 2,566 tourists. It was only in 2013 that the tourist arrivals approached the value of those from 2008 (9,457 tourists); subsequently, through spectacular increases and decreases, in 2018 only 8,010 tourists were registered.

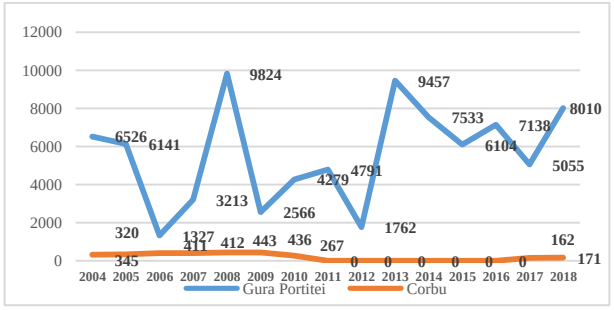

Figure 2 Tourist Arrivals in the Northern Peripheral Wilderness Area Between 2004-2018. Source: N.S.I.

Also, from the official statistical data, in Corbu locality there were, in 2008, 412 tourists. Subsequently, in the period 2011-2016 no tourist is registered, in 2017 only 162 and 171 in 2018. We do not have any statistical data about Vadu. As we mentioned, in reality the tourists who come to these areas are much more numerous.

Statistical data are available on tourist arrivals for the other localities in the Northern Core-Periphery Area, grouped as follows: Navodari City with Navodari Resort (Mamaia Nord), Mamaia Resort with the center of Constanta and Eforie Nord with Eforie Sud.

The city of Navodari, together with Navodari Resort (Mamaia Nord) had in 2018 70,518 arrivals. A significant increase of approximately six times higher than in 2008 (12,347 arrivals) was registered in Nord Periphery no. 2, with approximately half in 2013: 33,289 arrivals.

Five years after the global economic crisis, Constanta and the *Pearl* of the Romanian seaside – Mamaia, recovered bringing a record of 575,698 tourists; in 2008 there were only 461,086 tourists, with a slight decrease in 2013 - 436,546 arrivals.

Peripheral area no. 3 in the North also attracts a significant number of tourists. The two Eforie resorts have a slight growth trend of 1.50% in 10 years (2008 - 145,222 arrivals, 2018 - 218,813 arrivals), although in 2013 it had a decrease of 20 % (117,380 arrivals). Techirghiol has a steady increase

of 1.80%, from 8,636 arrivals in 2008 to 15,611 arrivals in 2018.

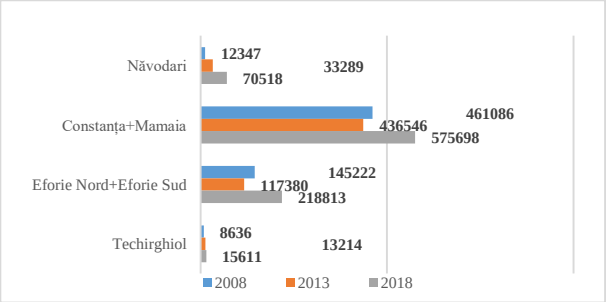

Figure 3 Tourist Arrivals in the Northern Core-Periphery Area Between 2008-2018. Source: N.S.I.

The tourist arrivals in Constanta County, depending on the seasonality, show the following:

- in 2018, 89% of the total number of tourists were registered in May-September, and in July-August there was a maximum of consumers (approximately $^2/_3$ of them): 62.30%;

- the share remained relatively constant between 2013-2018, thus in 2014 88.60% of tourists were reported in the season, of which 64.20% during the peak;

- foreign tourists increased 17.30% in the off-season, being more numerous (27.50%) than the Romanian ones (10.20%);

- the number of foreign tourists remained small (below 5%), the growth rate being half that of Romanian tourists.

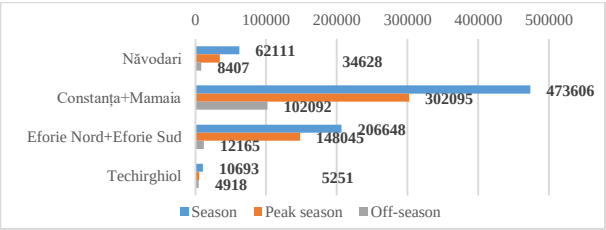

Figure 4 Seasonality of Tourist Demand in the Core-Periphery Area in the North (Tourist Arrivals). Source: N.S.I.

In the North Area, the seasonality of tourist arrivals is as follows:

- in Navodari, out of a maximum number of 62,111 arrivals, 55.75% of them were made during the peak season: 34,628 registered arrivals. In the off-season, there were less than 15% (8,407 arrivals);

- in Constanta and Mamaia, the area with the highest records regarding the number of tourists arriving on the seaside, 63.80% (302,095) of the reported arrivals were in the peak season (out of a total of 473,606 arrivals); in the off-season, there were just over 100,000 arrivals;

- Eforie Nord and Eforie Sud were the busiest in the peak season (71.60% of tourists, 148,045 registered arrivals), here a total of 206,648 tourist arrivals were reported. In the off-season, there was an extremely small number of 12,165 tourists;

- Techirghiol is almost constant during the year, both in season and in the off-season, due to the spa treatments that are also performed in winter. Thus, while in the off-season there were 4,918 arrivals, only 5,251 arrivals are reported in maximum peak out of a total of 10,693 registered arrivals.

b) Tourist Overnight Stays

Regarding the number of overnight stays, the first place is held by the Municipality of Constanta (35.30%), followed by Eforie (18.80%), Navodari (4.50%) and Techirghiol (2.6%), all the others having a share of less than 1%.

The most dynamic resort was Navodari (Mamaia Nord) which recorded an increase of 607.80% (from 37,453 to 227,636 overnight stays), followed by 140.20% in Techirghiol (increase from 94,498 to 132,496 overnight stays), 131.10% in Eforie Nord and Eforie Sud (from 718,635 to 942,290 overnight stays, with a decrease of 59.60% - 450,268 overnight stays in 2013) and 105.20% in Mamaia (from 1,679,252 to 1,767,115 overnight stays, with a decrease of 18.50% - 1,406,403 overnight stays in 2013).

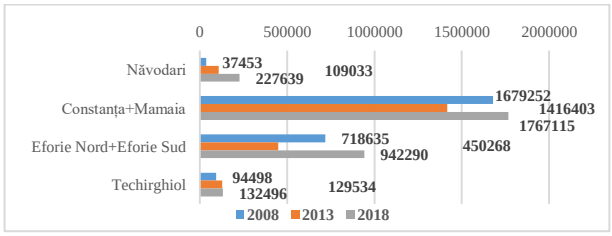

Figure 5 Tourist Overnight Stays in The Northern Core-Periphery Area Between 2008-2018. Source: N.S.I.

Regarding the number of overnight stays, the discrepancies are very large, as follows:

- in 2018: 67.60% of the overnight stays at the peak of the season, out of a total of 92.20% in the whole Constanta county;

- in the off-season only 25.30% of the overnight stays of foreign tourists are reported and only 7.30% of the overnight stays of Romanian ones;

- the share of overnight stays of tourists barely reaches 3.80% and decreases continuously (during 2014-2018 it decreased by 18.50%), the reason being the decrease of the average length of stay from 4.6 to 3.1 tourist-days;

- in the summer season there is a high concentration of tourists in the tourist localities on the seaside;

- Eforie Nord and Eforie Sud comprise 94.40% of the number of tourists and 96.30% of the number of overnight stays take place during the season.

- the pressure exerted by the peak season is slightly lower, only 67.70% tourists and 70.20% overnight stays being recorded;

- in Techirghiol, a spa locality, less dependent on the changes of the seasons, the seasonality is not much affected, 31.50% tourists and 38.80% overnight stays being recorded.

In Navodari, out of a total of 215,482 overnight stays throughout the season, 138,683 take place during the peak period and only 12,157 overnight stays were recorded in the off-season.

Constanta and Mamaia have the most overnight stays on the entire seaside, respectively 1,554,762 overnight stays, of which 1,060,728 take place in the peak season; tourists that come in the off-season have only 212,353 nights.

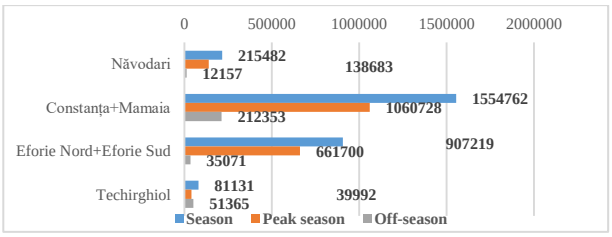

Figure 6 Seasonality of Tourist Demand in the Northern Core - Periphery Area (Tourist Overnight). Source: N.S.I.

Eforie Nord and Eforie Sud have just over 900,000 overnight stays, of which 661,600 are in season, to which are added 35,071 off-season overnight stays.

Techirghiol has a special configuration, the number of arrivals in the off-season is almost two thirds higher than that of arrivals in the peak season (51,365 to 39,992 overnight stays), with a total of 81,131 overnight stays.

c) Length of Stay

With the exception of the city of Navodari which had an increase of 6.60% (from 3 tourist-days to 3.2 tourist-days, with a maximum in 2013 of 3.3 tourist-days), all other tourist destinations registered constant decreases: -16.12% in Mamaia (from 3.6 to 3.1 tourist-days), - 13.95% in Eforie Nord and Eforie Sud (from 4.9 to 4.3 tourist-days) and 28.23% in Techirghiol (from 10.9 to 8.5 tourist-days). Noteworthy is the big difference between the average lengths of stay recorded in Techirghiol and the other localities because it is a spa resort destination, and the treatments require time to have the expected effect.

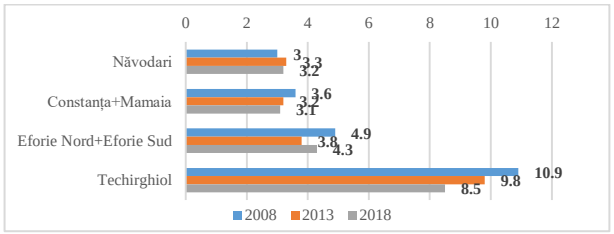

Figure 7 Length Of Stay (Number Of Days) In The Northern Core-Periphery Area Between 2008-2018. Source: N.S.I.

3.2 Southern Core-Periphery Area

As in the Northern Core-Periphery Area, statistical data on tourist arrivals from some resorts were calculated together with other resorts. Thus, the following groups are formed:

- The Mangalia core was grouped with the resorts located in the Peripheral Area no. 2 from the South, i.e. those from the Comorova Forest Area: Neptun- Olimp Jupiter, Cap Aurora, Venus, Saturn;

- Peripheral Area no. 3 from the South was calculated together, being a relatively small number: 2 Mai and Vama Veche;

Here too, as in the Peripheral Area no. 1 in the North, the wild and semi-wild resorts were occupied by tourists, who stayed with the locals, in tents (outside the campsites) or in their own cars and they were not reported anywhere. However, consumption in food service structures shows, at least in the statistical data, a large presence, which is actually observed on the beach.

a) Tourist Arrivals

The most spectacular increase was in the 2 Mai-Vama Veche group, of 465.30% (from 3,720 to 17,323 arrivals), followed by Costinesti with 232.40% (from 23,926 to 55,608 arrivals) and Mangalia with the Comorova Forest Area with approximately 111.90% (from 303,762 to 339,824 arrivals).

It can be noticed that the Southern Area does not cover even by far the number of arrivals from the Northern Area (Constanta with Mamaia), with differences of more than twice as big:

- In 2008 there were 331,411 arrivals in the South Area compared to 627,291 arrivals in the North Area (representing - 47.17%);

- in 2013 a difference of 58.86% is reported between the two Areas (247,016 compared to 600,429 arrivals);

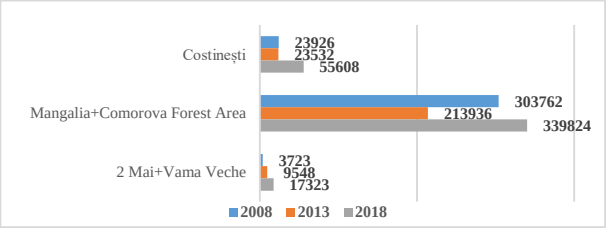

Figure 8 Tourist Arrivals in the Southern Core-Periphery Area Between 2008-2018. Source: N.S.I.

- in 2018 the difference is slightly smaller than in 2013 (by 5.73%), the number of those arriving being 880,640 in the North Area and 412,755 in the South Area (-53.13%).

The South Center, represented by Mangalia and the six resorts in the Peripheral Area no. 2 from the South, mentioned above, did not exceed the number of tourists who arrived in 2008 in the North Center, represented by the Municipality of Constanta and Mamaia Resort (461,086), reaching 303,762. Then, not even 5 years after the global economic crisis, the number of tourist arrivals from the South Core did not reach the one in the North: 213,936 versus 436,546 times in 2018. In the South Core 339,824 tourists arrived compared to 575,698, arriving in the North.

Regarding the two rural areas in the south, i.e. Periphery no. 1 from the South – Costinesti – and Periphery no. 3 from the South – Limanu Commune (with the resorts 2 Mai and Vama Veche) –, even in the case of taking them into account together the number of tourists (in 2018 there were 72,931) does not reach the one of the two Eforie resorts: 218,813, but slightly exceeds the one from Navodari Resort and Navodari City, from Periphery no. 2 from the North: 70,518 tourists.

In the South, things are a little different:

- in Costinesti, 55,508 tourists arrive, of which 49,588 arrivals are registered in the peak season, which represents 89.30%, being the busiest resort in this period; in the off-season, no tourists step on the sea shore;

- Mangalia and the localities around it from Comorova Forest have the most work during the peak season when 258,989 tourists arrive, considering that 330,756 tourists are registered throughout the season. In the off-season, there are almost 10,000 tourists who benefit from spa treatments;

- in Limanu (2 Mai and Vama Veche) the same strong activity is maintained during the peak season (12,685 arrivals), with a total of 17,184 tourists coming there during the season. In the off-season, 139 tourists were registered.

-

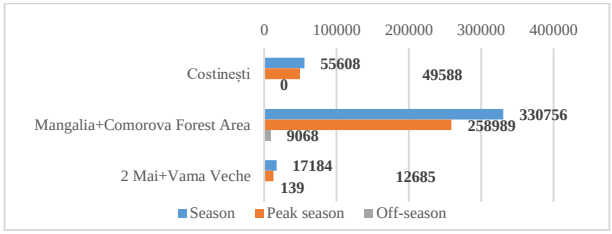

Figure 9 Seasonality of Tourist Demand in the Southern Core-Periphery Area (Tourist Arrivals). Source: N.S.I.

b) Tourist Overnight Stays

Regarding the number of overnight stays, the first place is held by the Municipality of Mangalia (32.70%), followed by Costinesti (4.20%) and Limanu (1.10%). All other localities in the South, as we have shown, attracted less than 0.80% of the number of overnight stays recorded.

The most spectacular increase was in the commune of Limanu (Vama Veche and 2 Mai) with about 192.10%, followed by the resorts of Costinesti (+ 87.80%), Ovidiu (+ 50.50%) and Venus (+40, 20%).

Costinesti resort had an increase of 87.80% in 2018 compared to 2008 (from 110,812 to 208,096 overnight stays), even if in 2013 it had a decrease to 93,446 overnight stays (-15.68%).

Mangalia and Comorova Forest Area recorded a decrease of 5.70% compared to 2008 (from 1,739,522 to 1,640,192 overnight stays), but had an increase of 27.90% compared to 2013 (1,155,230 overnight stays).

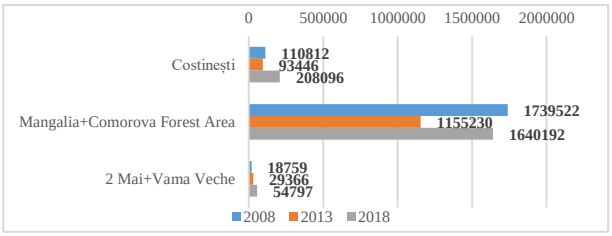

Figure 10 Tourist Overnight Stays in the Southern Core-Periphery Area Between 2008-2018. Source: N.S.I

Regarding the number of overnight stays, the discrepancies are very large, as follows:

- in 2018: 67.60% of the overnight stays at the peak of the season, out of a total of 92.20% in the whole Constanta county;

- in the off-season only 25.30% of the overnight stays of foreign tourists are reported and only 7.30% of the overnight stays of Romanian ones;

- the share of overnight stays of tourists barely reaches 3.80% and decreases continuously (during 2014-2018 it decreased by 18.50%), the reason being the decrease of the average length of stay from 4.6 to 3.1 tourist days;

- in the summer season there is a high concentration of tourists in the tourist localities on the seaside;

- Eforie Nord and Eforie Sud comprise 94.40% of the number of tourists and 96.30% of the number of overnight stays take place during the season.

- the pressure exerted by the peak season is slightly lower, with only 67.70% tourists and 70.20% overnight stays being recorded;

- in Techirghiol, a locality with a spa treatment option, less dependent on the changes of the seasons, the seasonality is not much affected, with 31.50% tourists and 38.80% overnight stays being recorded.

In Navodari, out of a total of 215,482 overnight stays throughout the season, 138,683 take place during the peak period and only 12,157 overnight stays were recorded in the off-season.

Constanta and Mamaia have the most overnight stays on the entire seaside, respectively 1,554,762 overnight stays, of which 1,060,728 take place in the peak season; tourists that come in the off-season have only 212,353 nights.

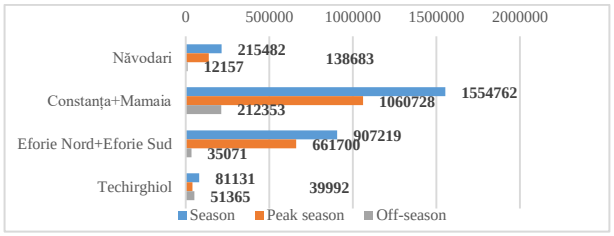

Figure 11 Seasonality of Tourist Demand in the Northern Core-Periphery Area (Tourist Overnight). Source: N.S.I.

Eforie Nord and Eforie Sud have just over 900,000 overnight stays, of which 661,600 are in season, to which are added 35,071 overnight stays.

Techirghiol has a special configuration, the number of arrivals in the off-season is almost two thirds higher than that of arrivals in the peak season (51,365 to 39,992 overnight stays), with a total of 81,131 overnight stays.

The following is noted in the analysis of the seasonality in the Southern Area of the seaside:

- Costinesti resort is exclusively seasonal, with 208,096 overnight stays being registered, of which 188,794 overnight stays are between July and August;

- similar situations, with a very small number of overnight stays in the off-season (for example, 442 overnight stays in Limanu Commune), are found in Mangalia, localities in the Comorova Forest Area (with the resorts Saturn, Venus, Cap Aurora, Jupiter and Neptun-Olimp), and the localities of 2 Mai and Vama Veche. And yet, the pressure during the peak period is less visible than in the case of Costinesti Resort, even if in Limanu Commune tourists generate 43,720 overnight stays out of a total of 54,315 overnight stays.

- those arriving in off-season in Mangalia and the seaside towns adjacent to the Comorova Forest come for spa treatments.

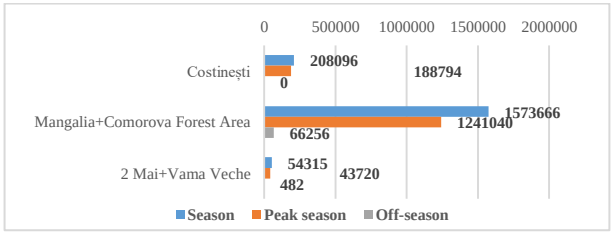

Figure 12 Seasonality of Tourist Demand In The Southern Core-Periphery Area (Tourist Overnight). Source: N.S.I.

c) Length of Stay

The length of stay in the resorts on the southern Black Sea seaside is generally positive, increasing between 11.80% and 56.20%.

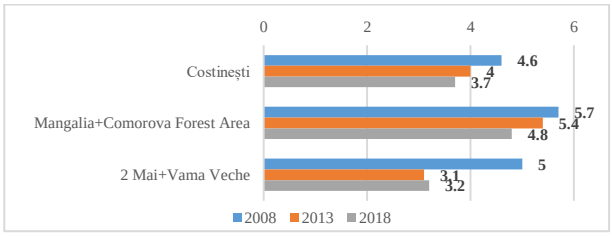

Figure 13 Length of Stay (Number of Days) in the Southern Core-Periphery Area Between 2008-2018. Source: N.S.I

The 2 Mai-Vama Veche area had the highest increase, of 56.20%, the duration of the stay increasing from 3.2 tourist-days (2008) to 5 tourist-days (2018). The lowest increase is found in the Mangalia - Comorova Forest Area, with only 11.80% (from 4.8 in 2008 to 5.7 tourist-days in 2018). Costinesti also had a constant increase, with 24.30%, starting from 3.7 tourist-days in 2008 to 4.6 tourist-days in 2018.

It is observed that compared to the Northern Core-Periphery Area (except Techirghiol), the number of overnight stays is about 2-3% higher: the reason is that young people prefer to come on weekends to cheap resorts which offer enough entertainment, and others prefer quiet family resorts in Mangalia and Comorova Forest.

3.3 Comparison between the Northern and the Southern Area

Seasonality is a basic feature of tourism activity, regardless of country or continent and there will always be a negative impact on the destination when there is a massive concentration of tourism demand. This impact will lead to effects such as the degree of satisfaction of tourists, on the labor force in the industry, on the environment, etc.

From the point of view of the Romanian tourism industry, the most affected region is the South-East, more precisely for the part in the immediate vicinity of the seaside.

a) Tourist Arrivals

The most visited destination on the seaside remains Constanta together with Mamaia Resort in the North Center in a percentage of 47.70%, followed by Mangalia and the Comorova Forest in the South with an average of 27.30%, the difference between them being a little over 74% .

In third place are Eforie Nord and Eforie Sud (North Area) with an average of 15%, followed by several areas below 5%: in the North Area, Navodari - 3.50%, Techirghiol - 1.20% , and in the South Area Costinesti - 3.10%, Limanu (2 Mai and Vama Veche) - 0.93%.

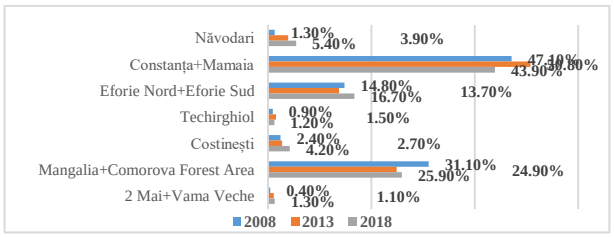

Figure 14 Tourist Arrivals (%) in the Northern Vs. the Southern Core-Periphery Area Between 2008-2018. Source: N.S.I

The analysis of this dynamic highlights the fact that tourists prefer the Northern Area, more precisely the most strongly developed on the seaside, Mamaia. This can be seen in the relatively large increases in Navodari, Limanu or Techirghiol, but the distribution is based on several conditions that will be analyzed later.

In absolute numbers, the largest increases were noted in the Municipality of Constanta, where, in 2018, 114,612 more tourists stayed than in 2008 and 139,152 more tourists compared to 2013.

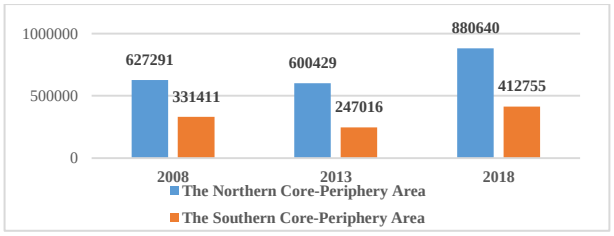

Figure 15 Tourist Arrivals in the Northern Vs. The Southern Core-Periphery Area Between 2008-2018. Source: N.S.I.

Using the data of the National Institute of Statistics for 2018, it can be seen that in 2018 the Romanian seaside received the most tourists from the entire county of Constanta.

b) Overnight stays

The structure between the North and the South Area is preserved here as well. Thus, Constanta and Mamaia are around the average value of 38.20%, followed by Mangalia and the Comorova Forest Area with 35.20%. Tourists, at the level of 2018, reduced the number of overnight stays in the mentioned localities by approximately 7.30% in the North and by almost 19.90% in the South; thus we can notice, once again, the fact that tourists prefer the North more than the South.

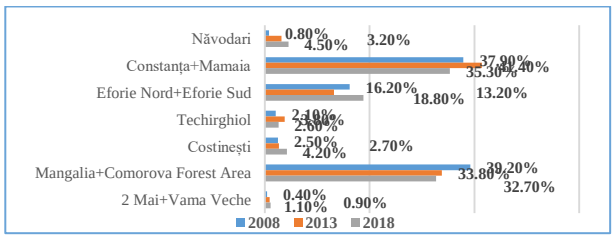

Figure 16 Tourist Overnight Stays (%) in the Northern Vs. the Southern Core-Periphery Area Between 2008-2018. Source: N.S.I.

A special structure is the annual distribution of the peaks of overnight stays:

- in 2008, Mangalia and the localities in the Comorova Forest Area reached a maximum of 39.20%, showing that tourists preferred either to go with family or friends.

- in 2013, 5 years after the world economic crisis, most tourists went to the Constanta-Mamaia group, wanting to have fun by the highest standards. Techirghiol, too, is gaining about 81% compared to 2008, taking tourists from the group of the two Eforie.

- in 2018, the influence of strong resorts decreases in favor of smaller resorts (Navodari, Eforie Nord and Eforie Sud in the North Area, respectively Costinesti and Limanu commune - 2 Mai and Vama Veche in the South area), a trend of stability in their choice being noticed.

And yet, in the battle of North versus South, the North wins, with a surplus of 2,654,396 nights spent by tourists on the seaside, which shows that the North will continue to have a demand from them in the coming years.

The number of overnight stays made by tourists in Constanta County shows that the largest agglomerations take place on the coastline dedicated for this purpose, occupying more than half of the 80 km located on Romanian territory. The farther we go from the shore, the number of tourists decreases to insignificant values, which are not taken into account in the present research.

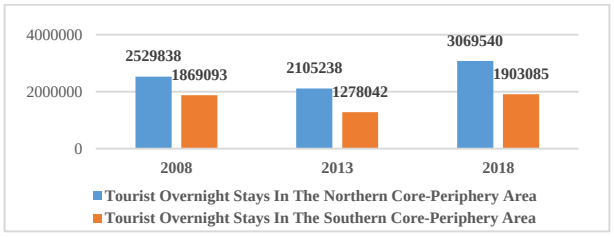

Figure 17 Tourist Overnight Stays in the Northern Vs. the Southern Core-Periphery Area. Source: N.S.I.

c) Length of stay

Spending the stay is a challenge for any commercial enterprise in the industry, which tries, by (almost) any means to keep the tourists close. However, according to reports, at the North-South level, the same trend of spending the stay in the North Area to the detriment of the South is occurring.

The decrease of tourist days during the stay in the Northern Area is approximately 17.40% (from 5.6 in 2018 to 4.77 tourist days in 2018), with the Southern Area losing more than 30.70% of their total in the same period (from 5.1 to 3.9 tourist days).

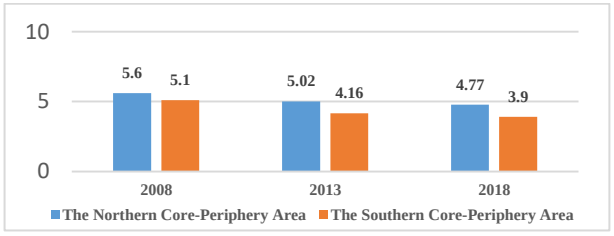

Figure 18 Length of Stay (Number of Days) in the Northern Core-Periphery Area Vs. the Southern Core-Periphery Area Between 2008-2018. Source: N.S.I.

d) Seasonality

1) Tourist arrivals

The seasonality of the tourist demand between the North and South Core-Periphery Area is shown in the graph below:

- *The North Core-Periphery Area*:

a) Navodari Resort: out of the total number of tourists arriving here, 11.90% come in the off-season, and 49.10% of them come in the peak season;

b) in Constanta and Mamaia: 17.20% come in the off-season, 52.50% in the peak season and only 29.80% come in the rest of the time;

c) Eforie Nord and Eforie Sud: most tourists arrive during the peak period (67.70%), with few of them coming in the off-season (5.60%);

d) Techirgiol: breaks the record for arrivals in the off-season (31.50%), almost at the same value as those coming in the peak season: 33.60%.

- *The South Core-Periphery Area*:

a) Costinesti: has the highest number of arrivals in the peak season on the Romanian seaside (89.20%), not being appreciated in the off-season (0.00%);

b) Mangalia and the localities from the Comorova Forest Area: in the off-season very few come, only 2.70%, the peak of the season being the most appreciated in this resort (76.20%).

c) Limanu Commune (2 Mai and Vama Veche localities): arrivals in the off-season are insignificant (only 0.80%), the arrivals from the peak season being 73.20%).

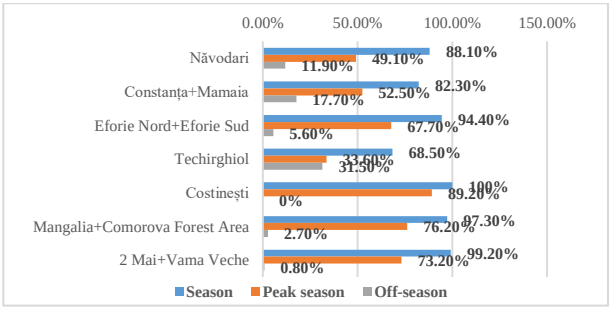

Figure 19 Seasonality of Tourist Demand in the Northern Versus the Southern Core-Periphery Area. Source: N.S.I.

Looking at these data, we conclude that tourists appreciate the North more than the South during the summer season, but the ratio is reversed, with more tourists coming to the South during the off-season.

The exceptions are the following: in Techirghiol, in the off-season, we have the highest number of arrivals, and in Costinesti no arrivals. The reason is, as we have shown, that Techirgiol has treatment complexes that work all year round.

The distributions of arrivals are very clear comparing the two Areas: most prefer the summer season, of which more than half come in the peak season. Arrivals in the off-season are only 38.50% higher in the North than in the South.

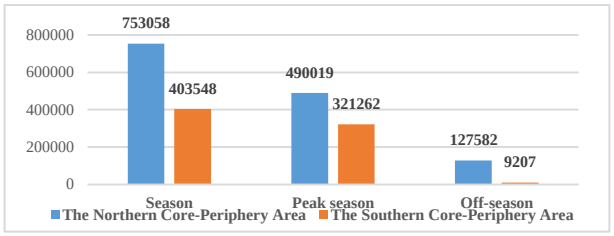

Figure 20 Seasonality of Tourist Arrivals in the Northern Versus the Southern Core-Periphery Area (Tourist Arrivals). Source: N.S.I.

2) Overnight stays

The conclusions drawn from the overnight stays in terms of seasonality show that most tourists prefer to come at the peak of the season (from 60.00% in Constanta and Mamaia to 90.70% in Costinesti), with relatively few tourists in the off-season (12.00% in Constanta and Mamaia) or not at all (0.00% in Costinesti).

The exception to this rule is Techirghiol, which, having open treatment spas (treatment that requires time to alleviate diseases), works all year round. Let us not forget that, in winter, the prices in the accommodation offers are much lower than in season or in the peak one, thus more and more tourists come here out of season.

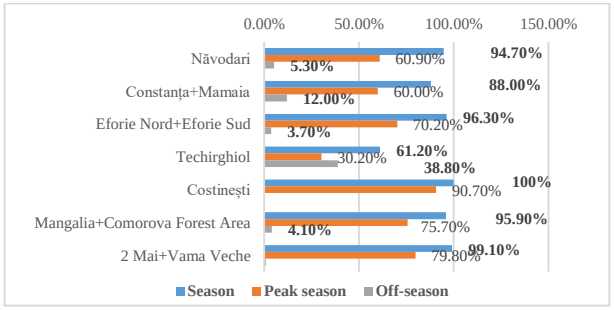

Figure 21 Seasonality of Tourist Demand in the North Versus the Southern Core-Periphery Area (Tourist Overnight). Source: N.S.I.

The differences obtained as a result of the processing show that the Northern Area is also more prolific in terms of overnight stays, the differences between the two being 33.40% during the summer season, 22.50% in the peak season and 78.50%. in the off-season.

We can also see here that in the peak season most tourists spend the night on the Romanian seaside, due to the high and long-lasting temperatures during the summer and employers grant the period of compulsory leave in July-August.

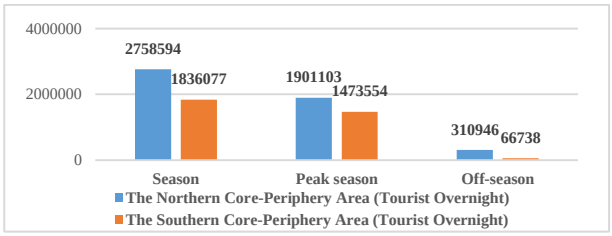

Figure 22 Seasonality of Tourist Demand in the Northern Versus the Southern Core-Periphery Area. Source: N.S.I.

e) Tourism Demand-Supply Ratio

The index that links supply and demand is called the *occupancy rate* (index of net use of accommodation). It highlights the degree to which accommodation capacities are capitalized in terms of overnight stays.

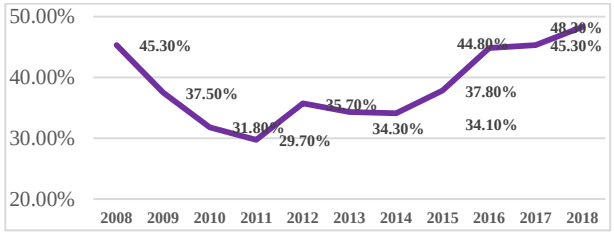

Figure 23 Index of Net Use of Accommodation Places on The Seaside (2008-2018)Source: N.S.I.

In terms of developments in the last decade (2008-2018), three distinct periods are identified:

- period 2008-2011: against the background of the economic crisis, all indices decrease, the occupancy rate decreasing by 15.60 pp, from 45.30% to 29.70%;

- 2012-2014: the index is recovering, but not strong enough to hold. Thus, although in 2013 it reaches 35.70%, it then decreases by 1.20 pp (*percentage points*);

- 2014-2018: following the return of world economic exchanges, there is a steady increase in the index of net use of accommodation, from 34.10% to 48.30%.

Following the curve for the decade 2008-2018, we can see that only after 9 years the occupancy rate reached the same level in the first year (45.30%). Another observation found is that the annual average occupancy is usually below 50% of the total operating accommodation capacity.

Perhaps it is useful to show the evolution of the occupancy rate of accommodation structures during 2018. As expected, based on previous analyses, there are very large differences between the maximum peak of the season (July-August) and the other months of year, given that in the off-season many units close.

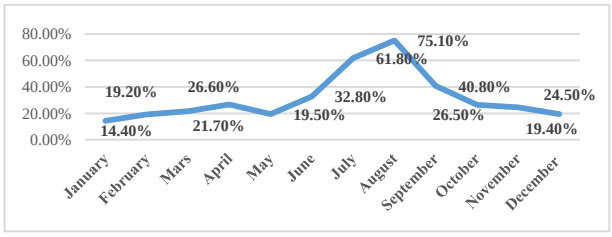

Figure 24 Index of Net Use of Accommodation Places on The Seaside (Every Month, 2018)Source: N.S.I.

Therefore, a large share of accommodation structures operate at a loss (almost 25% of them do not have enough tourists in the peak season), and in these conditions many of them close in the off-season to reduce losses.

In order to increase the value of the index of net use of accommodation structures, it is necessary, among others, to extend the summer season, both at hotel and destination level.

4. CONCLUSIONS

Following the analysis carried out throughout this article, we can observe that the Northern Core-Periphery Area is stronger than the South one in all respects. The fact that more and more customers are investing in this area also attracts the most customers.

A 2015 report of the National Bureau of Economic Research from the United States (*https://www.nber.org*) shows that, from any position we look (geographical, economic, etc.), the northern part will be more developed than the south, being influenced by four factors: it has access to the sea, natural resources, good conditions for agriculture, and the climate is cold or warm.

In the case of our country, and especially on the Black Sea seaside, the northern part meets all four requirements, while the south meets only three, lacking agriculture.

From the Danube Delta to Eforie Nord there is a flat, rich plateau, beneficial to the economy, while the south, as a remnant of prehistoric mountains,

has high, stony cliffs, being ruinous in terms of certain branches.

This hypothesis of American researchers is much richer in examples; however, if we adapt it to our country, we can notice that the choice of localities within the North-South Core-Periphery Areas is not purely coincidental, the differences being visible in the analyses.

From the point of view of the influences of the administrative-territorial units, as they are structured, the choice of these areas is the correct one and, in addition, all studies tend to take these details into account.

In conclusion, the North Area is, on average, 50% stronger in all domains (especially economical) than the South one, having the greatest influence in the analyses carried out so far.

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Review of Geodiversity and Geoheritage related sessions at the European Geosciences Union General Assemblies

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Abstract. Sessions related to geoheritage have been held under different convenorships and titles since 2012 at the European Geosciences Union General Assembly in Vienna. 2020 was a special year, since the session was held online. The author participated with a contribution in 2019 and without one in 2020, and it was an occasion to compare a physical session with oral and poster presentations and a splinter meeting to a digital session.

Keywords: *geopark, Chaîne des Puys, Piedmont, rural landscape, geoproduct, agricultural landscape, natural heritage*

1. OVERVIEW

Since 2012, a series of sessions on geodiversity and geoheritage has been held at the European Geosciences Union in Vienna, co-organised by different divisions, including education and outreach sessions. The titles and topics have changed over the years, while still touching on geodiversity and geoheritage, and so have the contributed papers. At the beginning, the same three conveners organised the session, but then the number grew, and the main convener rotated. A review of the first edition was provided by Vasiljevic (2012). Some of the papers were published (e.g. Coratza and Panizza, 2017).

2. EVOLUTION AFTER YEARS

The rows below list the years when the sessions were held, the organising divisions, exact titles, conveners, and topics covered.

- 2012: SSS12.3/EOS11 Geodiversity and geoheritage in university education and research (co-organized). Convener: E. Cammeraat | Co-Conveners: E. Reynard, H. van den Ancker.

The topics tackled in 2012 were: overview of university teaching and research programmes; regional geoheritage studies – from inventory and classification to practical use (tourism and culture); geodiversity; new tools for teaching; methods, discussions; geodiversity, nature management and spatial planning.

- 2013: SSS6.3/GM1.5 Geodiversity and geoheritage in geoscience research (co-organized). Convener: Emmanuel Reynard | Co-Conveners: Hanneke van den Ancker, Erik Cammeraat.

In 2013, the topics for oral presentations were scientific issues and methodological issues. Poster topics covered a wider range: geodiversity, geoheritage inventories, geoheritage management, and dissemination of knowledge on geoheritage.

- 2014: SSS1.2/GM1.12 Geoheritage: Integrating geo- and biodiversity research (co-organized). Convener: Emmanuel Reynard | Co-Conveners: Grazina Skridlaite, Hanneke van den Ancker.

In 2014, the topics linked geodiversity and biodiversity, and geodiversity and geoheritage.

- 2015: SSS9.11/EOS10/GM4.4 Geoheritage, Geodiversity and Landscapes: a key issue for present and future studies (co-organized).

Conveners: Paola Coratza, Zbigniew Zwoliński, Benjamin van Wyk de Vries | Co-Conveners: Marco Giardino, Alicja Najwer, Hanneke van den Ancker, Sjoerd Kluiving, Emmanuel Reynard, Erika Vye, Thomas Kisser, Stefanie Zecha (including a splinter meeting, and a town hall meeting on TM6. World Heritage Perspectives and the Chaîne des Puys and Limagne Fault Project, Convener: Benjamin van Wyk de Vries.

In 2015, the topics were geodiversity, geoheritage and cultural landscape; geodiversity, geoheritage and geomorphology; geodiversity, geoheritage and geoconservation-enhancement; geodiversity, geoheritage and education.

- 2016: SSS3.6/EOS7 Geoheritage and Geodiversity Matter: Themes, Links and Interactions (co-organized). Conveners: Paola Coratza, Benjamin van Wyk de Vries, Zbigniew Zwoliński | Co-Conveners: Marco Giardino, Hanneke van den Ancker, Emmanuel Reynard, Sjoerd Kluiving, Thomas Kisser, Alicja Najwer, Erika Vye, Stefanie Zecha

In 2016, the topics were geodiversity and geoheritage: definitions and methods; the relationship between geodiversity, biodiversity and cultural heritage; education, conservation and geotourism.

- 2017: GM1.3/EOS19/SSS3.12 Geodiversity and Geoheritage (co-organized). Conveners: Paola Coratza, Zbigniew Zwoliński, Benjamin van Wyk de Vries | Co-Conveners: Marco Giardino, Emmanuel Reynard, Hanneke van den Ancker, Sjoerd Kluiving, Alicja Najwer, Erika Vye, Stefanie Zecha, Kevin Page (including a splinter meeting)

In 2017, the topics were simply geoheritage and geodiversity.

- 2018: GM1.6/EOS19 Geodiversity and geoheritage: pending and emerging issues and challenges (co-sponsored by JpGU) (co-organized). Convener: Fabien Hobléa | Co-Conveners: José Brilha, Paola Coratza, Marco Giardino, Kevin Page, Dolores Pereira, Zbigniew Zwoliński, Alicja Najwer (including a splinter meeting).

In 2018, the topics were geodiversity and geoheritage concepts and methods: looking for standards?; geoheritage and heritage stones as cultural resources for facing global change and natural risk (Protecting Geodiversity, Geoheritage and Heritage Stones); innovative concepts, initiatives and experiences in geoheritage and geodiversity management and promotion; geodiversity and geoheritage within UNESCO World Heritage sites and Geoparks.

- 2019: ITS3.9/GM6.1/ERE7.4/GMPV7.15/ SSS13.29 Geodiversity and Geoheritage (co-sponsored by JpGU). Convener: Marco Giardino | Co-conveners: Paola Coratza, Alicja Najwer, Karoly Nemeth, Benjamin van Wyk de Vries (including a splinter meeting).

In 2019, the topics were society, climate change and geodiversity; geo- to ecosystem services and geoheritage; towards a fruitful integration/ collaboration of international designations, geodiversity, geosites and geoheritage analysis at multiple spatial scales, virtual and augmented reality, and geoheritage.

- 2020: GM12.1 Co-organized by EOS6, co-sponsored by APG and IAG Essential variables influencing geodiversity: contributions to geoheritage in response to global change. Convener: Zbigniew Zwoliński | Co-conveners: Irene Bollati, Paola Coratza, Marco Giardino, Franziska Schrodt

As the 2020 session was held online, there were no more subdivisions of topics.

The abbreviations stand for:

European Geosciences Union divisions:

SSS = Soil System Sciences
EOS = Education and Outreach Sessions
GM = Geomorphology
ITS = Inter- and Trans-disciplinary Sessions
ERE = Energy, Resources and the Environment
GMPV = Geochemistry, Mineralogy, Petrology & Volcanology

Co-organisers:

IAG = International Association of Geomorphologists
APG = Association of Polish Geomorphologists

3. DISCUSSION AND CONCLUSIONS

Figure 1 shows how the number of contributions varied over years, from one to four oral blocks and posters, respectively. The papers focused either on methods, as already mentioned, or on case studies. Most case studies were presented as posters, and covered both geodiversity and geoheritage. Figure 2

shows an overview of the geographical distribution of case studies, using a different colour for each year. As it can be seen, while the reach is global, the focus was on Europe, for which a detailed view is provided. Figure 3 shows the ratio between case studies and methodologies.

At times, case studies tackle common approaches in a given country, while in others specific sites are presented (e.g. a city for geodiversity, or a national park for geoheritage). Some case studies are brought back as new data becomes available, e.g. Piedmont (Giordano et al, 2016, Rolfo et al, 2015, to name just a few publications), or the Dutch landscape paintings, Tenerife, Emilia Appenines that focused on mud volcanoes. A case that re-emerged over several years was the UNESCO proposal for Chaîne des Puys. In this context, IUCN's designations were dealt with repeatedly, while a number of other papers dealt with geoparks.

The previously mentioned location, the Piedmont region, was covered by a (co)convener of the conference a number of times, and was visited by the author of the review in 2018, in the context of the MoMoWo conference, when the author participated in the session on "Women and tourism", which covered first women tourists in the Alps. Excursions explored the heritage of Turin (Fig. 4), which in the EGU context was covered by Borghi et al, 2014, in a paper on the stone material used in the city seen as geoheritage. This was not entirely new to the author, who in 2006 organised a session on the topic GMPV10 "Challenges to historical materials in urban/anthropic environment", which later on resulted in a book (Bostenaru et al, 2009) in synergy with the running series on "Natural stone resources for historical monuments" convened by Richard Prykril, Ákos Török and collaborators. The topic is also relevant for the other site of Chaîne des Puys (Vereb et al, 2020). Excursions in the surroundings were made to explore Ivrea, which at the time was being reviewed as a World Heritage Site, and discussions were later on held on Susa Valley and Grande Traversata delle Alpi.

The author of the review participated at the 2019 session with a presentation on Rome's geoheritage (a previously approached topic) and experienced a part of the traditional oral and poster blocks, and also attended the splinter meeting, an event featured most years. The splinter meeting was dedicated to geoproducts. This is a typical approach for landscape conferences. For example, the Le Notre conferences also feature field trips and local food. In 2018, at the final COST RELY conference, co-organized with PECSRL (Permanent European Conference for the Study of the Rural Landscape), the author had the occasion to experience the Chaîne des Puys landscape to which, in one of the previous years, this session dedicated a town hall meeting (Bostenaru, 2020). The PECSRL conference allowed participants to discover the topics it featured, from the geodiversity of Clermont-Ferrand, which was also the subject of a presentation held at the EGU conference (published in Vereb et al, 2020), to geoproducts sourced in the natural park in numerous field trips, along with the landscape itself, which participants were able to choose to discover and enjoy by train, bus or trekking (Fig. 5).While the splinter meeting featured local geoproducts, the actual landscape – a landscape of pastoralism – was presented through photographs. Moreover, participants were handed flyers that presented strategies implemented by international associations on the topics that were being discussed.

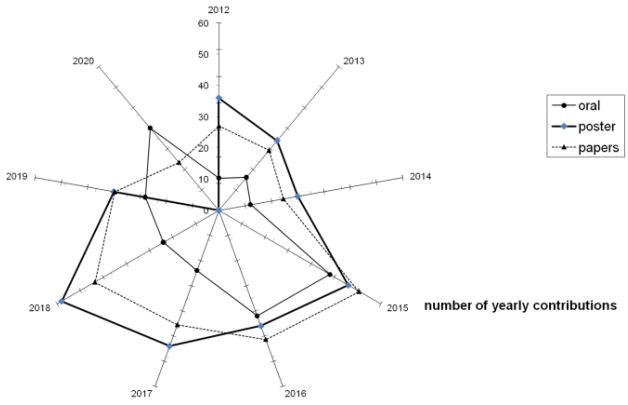

Figure 1 Number of yearly contributions

The digital Sharing Geoscience Online was organised by the EGU in several phases. Presentations could be uploaded so that participants could view and discuss them prior to and after the conference (one month before, and one month after the conference). During the conference, participants could communicate via an unrecorded group chat, which also introduced the so-called *displays* that

allowed users to submit PPT and video files, and then the floor was open to questions. This way, significantly more questions could be asked. A special issue in a MDPI journal is currently being planned.

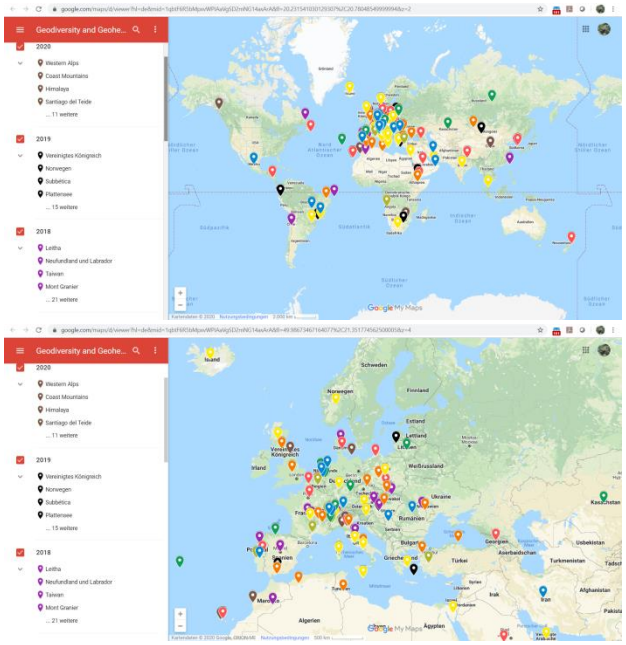

Figure 2 Map of case studies: worldwide and focus on Europe. Full map available here: https://www.google.com/maps/d/drive?state=%7B%22ids%22%3A%5B%221qbtF6R5bMpxvWPIAaVgSD2mNG14asArA%22%5D%2C%22action%22%3A%22open%22%2C%22userId%22%3A%221032452028278614217 92%22%7D&usp=sharing

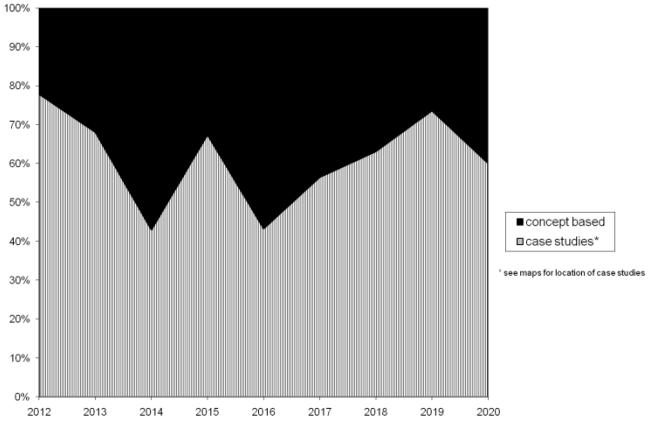

Figure 3 Number of concept based research abstracts/case studies

Figure 4 Piedmont region: World Heritage Site Ivrea and the Piedmont Alps landscape, Stone ornaments at the Architecture Faculty (Photos: M. Bostenaru), Susa, the valley covered by the study and local alpine landscape (Photos: J. Meinecke)

Figure 5 Chaîne des Puys landscape: volcanic geodiversity in Clermont-Ferrand, agriculture for geoproducts, "sur les chemins noirs" accommodation in a hamlet, Puy Mary volcano, similar to the UNESCO site. Photos: M. Bostenaru

Although it was not a visual session, such as Zoom-supported conferences or slide-based presentations, in order to account for the large number of attendees and their potential technical issues, the chat was a slow and tiring medium. Consequently, the conveners opted for a google doc to collect questions and answers (a unique option among sessions), which was also used to archive the session. A larger number of attendees could join, similarly to physical meetings.

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Report from the first workshop of International Permafrost Association Action Group Rock glaciers inventories and kinematics

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Abstract. The recent initiative to standardize the mapping and monitoring of rock glaciers around the world resulted in the organization of the First Workshop of the Action Group Rock glaciers inventories and kinematics, in Evolene, Switzerland. The participants focused to discuss in detail and debate several issues to be introduced in a new version of a guidelines document regarding rock glaciers inventorying. This paper discusses the development of the field trips and working sessions of the workshop.

Keywords: *rock glaciers, mountain permafrost, action group, workshop, International Permafrost Association*

1. INTRODUCTION

Rock glaciers are permafrost containing landforms in mountain areas made of rocks and ice. They increased in importance in the last decades in the context of climate change because of two aspects: (1) in some countries with dryer climates where glaciers retreated significantly, rock glaciers become a more important water source for the summer river discharge (Rangecroft et al., 2015) and (2) in some areas it was documented an increment in rock glaciers velocities (Kääb et al., 2020) and an associated increase in sediment transfer rates that in several areas tend to threat the infrastructure. Also, rock glaciers even with a smaller content of ice in comparison to "true" glaciers, are considered more "resistant" to climate warming because of the insulating effect of debris mantle on top of permafrost (Jones et al., 2019).

In June 2018 the Action Group Rock glaciers and kinematics was founded under the auspices of International Permafrost Association (IPA) during the Fifth European Conference on Permafrost (EUCOP) held in Chamonix, France. The main goals of the group are (1) to standardize the rock glacier inventorying, (2) to prepare "products" for monitoring rock glaciers dynamics as a related parameter of permafrost ECV (essential climate variable) and (3) to create a worldwide rock glaciers data base and a web platform where data can be accessed.

On 23-27 September 2019 it took place the first workshop of the *Rock glaciers inventories and kinematics* Action Group in Evolène, in the canton of Valais, Switzerland. The workshop was dedicated to the first objective of the group, *i.e.* to define the guidelines for inventorying the rock glaciers. The importance of this issue resides from the nature of rock glaciers landforms, especially their limits that are sometimes very difficult to trace and thus exposed to subjectivity. In this respect, Francesco Brardinoni presented during the workshop a study that showed large inter-operator differences in identifying and delineating rock glaciers contours (Brardinoni et al., 2019). This is a major impediment for a global and consistent evaluation and monitoring of rock glacier phenomenon.

2. WORKSHOP FIELD TRIPS

Three days of the workshop were dedicated to two field trips. The first one targeted the Perroc active landslide and the Tsarmine active rock glacier (Valais Alps, Arolla). The landforms are spectacular and have a rich field monitoring data base. For Tsarmine rock glacier (Fig. 1, 2), in spite of the high activity rates (meters per year), most of the exposed boulders are covered with lichens indicating that rock fragments move mostly passive without rolling and that rock glaciers activity assessment only by lichen cover can be sometimes misleading.

Figure 1 Tsarmine rock glacier lateral view. At the right its front intersects a gully and thus it is affected by backwards erosion

Figure 2 Discussions below the Tsarmine rock glacier front (in the background) led by Reynald Delaloye, chair of the action group

The second field trip was conducted in the Haut Vallon de Réchy area and Lona catchment (Fig. 3), it lasted two days (night spent on Becs-de-Bosson alpine hut at 2985 m asl) with the aim to visit several types of rock glaciers (from relict to active) and some particular case studies with rock glaciers in former interaction with glaciers. Becs-de-Bosson, Tsavolire and Lona rock glaciers were the main objectives. For Becs-de-Bosson we learned that in the upper part of the rock glacier there is no permafrost because it is the former area of a Little Ice Age (LIA) glacier and also that rock glacier lobes even very close to each other can move different. For the northern lobe only the inside area moves differently while the front is very slow; the southern lobe moves very fast across its entire surface and creates a periglacial push moraine (Fig. 4), a type of landform that is not often mentioned in the literature. Tsavolire is an active rock glacier moving of about a meter/year despite a positive mean multiannual ground surface temperature (https://www3.unifr.ch/geo/geomorphology/en/resources/study-sites/tsavolire.html). Lona is a landform that most participants classified as a typical rock glacier but it is in fact a vast push moraine created by the LIA glacier but with typical rock glacier morphology. Permafrost is present only in the margins of the former glacier but downslope movement characterizes all the area of the landform. Another site of observation was dedicated to a complex of relict rock glaciers/moraines (Fig. 5). Several exercises on mapping rock glaciers and discussions about origin, relation to moraines and rock glacier activity were conducted in the field.

Figure 3 Workshop participants in the Haut Vallon de Réchy

Figure 4 Periglacial push moraine seen from below created by the advancing Becs-de-Bosson southern rock glacier lobe

Figure 5 Landform complex (moraines or relict rock glacier) west of Lona Pass

3. WORKSHOP SESSIONS

The field trips were followed by common sessions, presentations and work sessions in which there were presented and debated most of the details that have to be taken into account when performing a rock glacier inventory. For the work sessions, the group of participants was split into several small groups that discussed several topics concerning the following subjects:

- technical definition of rock glaciers;
- rock glaciers units;
- connection to the upslope unit;
- definition to the rock glaciers boundary;
- differentiation between rock glaciers and debris covered glaciers;
- rock glaciers activity;
- inventorying strategy;
- practical concepts for assessing activity;
- guidebook: structure and content;
- implementation: how to proceed.

I participated in the rock glaciers units (1) and definition to the rock glaciers boundary groups (2). Each session ended with a written document in which several issues were addressed and several topics were formulated in order to be included after a revision in a new version (3.0) of the document "Towards standard guidelines for inventorying rock glaciers" (the document can be seen here: https://www3.unifr.ch/geo/geomorphology/en/researes/ipa-action-group-rock-glacier/).

During the common sessions several presentations regarding rock glaciers were held:

- Risks and Opportunities of a Rock Glacier Inventory, by Lukas Arenson;
- Evaluating sources of uncertainty and variability in rock glacier inventories, by Francesco Brardinoni;
- The (Rock) Glacier Inventory of Argentina, by Lukas Ruiz;
- Frozen debris lobes from Alaska, by Margaret Darrow (included also an artistic moment).

4. CONCLUSIONS

There was a major opportunity to be together with many specialists in rock glaciers and mountain permafrost from around the world. According to the organizers, there were a total of 42 participants from 14 countries and 4 continents! Also, there was a great opportunity to visit in the field several types of rock glaciers including active ones and to be able to take part at on site discussions about mapping, formation, evolution, recent glacial-periglacial interactions and monitoring rock glaciers.

The results of this action group will solve a major problem in the scientific community in what concerns the reducing of uncertainties and subjectivity in rock glacier inventories and the necessary steps to use the rock glaciers and mountain permafrost as a proxy for climate variability monitoring.

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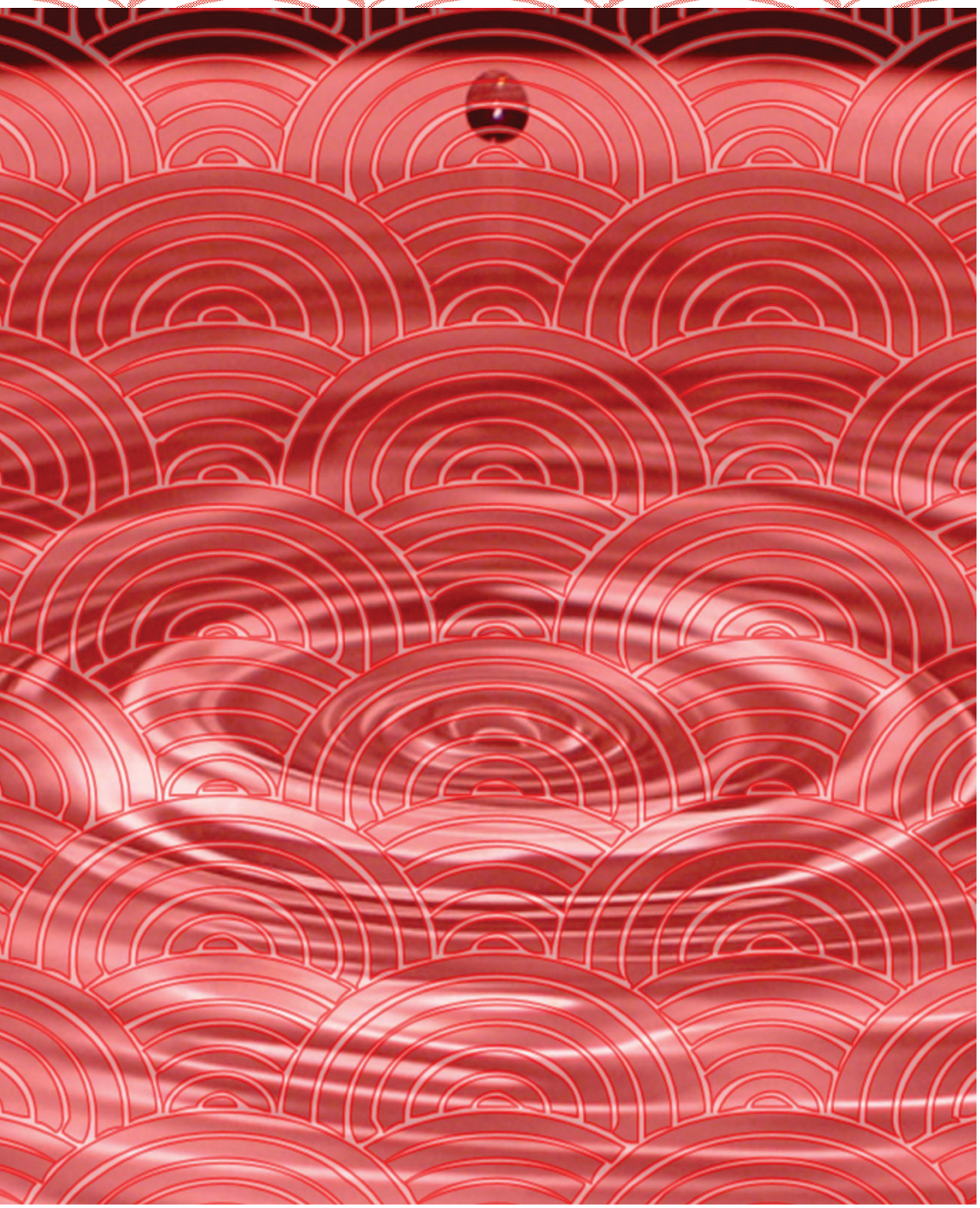

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