APPLICATION OF SINMAP AND ANALYSIS OF MODEL SENSITIVITY – CASE STUDIES FROM GERMANY AND CHINA

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Abstract. Landslides cause significant damage in many parts of the world and consequently many efforts have been made to forecast the spatial probability of future slope failures. In particular regional landslide susceptibility and hazard models have become popular over the last years because they delineate areas which are likely to experience slope failures in the future, which is important, e.g. for spatial planning purposes. In this study, the physically-based model SINMAP (Stability Index Mapping) was applied to two study areas with different geo-environmental conditions; one in the Swabian Alb, Germany, and one in Youfang catchment, Wudu county, Western China. A sensitivity analysis of the geotechnical input parameters was carried out to determine their influence on model outputs. The results show that the majority of observed landslides are located within areas that have been classified as likely to experience slope failure. The spatial resolution of input data has an effect on SINMAP results, however, the difference between 10 m and 30 m data was found to be relatively small. Sensitivity analysis revealed that internal friction has a large influence on susceptibility modelling, while the hydrological parameter *T/R* only changed the results to a very small extent under the parameter range tested in this study. Based on the results it can be concluded that SINMAP is capable of appropriately computing regional landslide susceptibility for large areas and can provide useful information, especially when high detail topography data is available. The results of sensitivity analysis can be expected to be helpful for other researchers for a more successful application of SINMAP to other study areas.

1. INTRODUCTION

Landslides are natural phenomena occurring in many parts of the world and their damage potential is often underestimated. A recent study by Petley (2012) concluded that between 2004 and 2010 32,322 lives were lost due to non-seismic-triggered landslide events, relating to an average annual death toll of approximately 4,617. In addition to fatalities due to catastrophic slope failures, landslides cause significant direct and indirect damage, for example due to destruction of infrastructure, blockages of roads and interruption of life-lines, as well as the degradation of agricultural land. For China, Yin (2009) estimated direct annual economic losses of approximately 10 billion RMB (approximately US-$ 1.65 billion) and 900 fatalities. Even in Germany with its relatively low fraction of high mountain areas, the annual damage has been calculated to be US-$ 150 million (Krauter, 1992).

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Fostered by the advances in computer technology and in particular the advent of Geographic Information Systems (GIS) in the 1990s, an increasing number of regional landslide susceptibility, hazard and risk maps were prepared to aid spatial planning and to avoid the consequences of slope failures (e.g. Catani *et al.*, 2005; Guzzetti *et al.*, 2005; Bell, 2007; Cascini, 2008; Chung, 2008; Fell *et al.*, 2008; Bai *et al.*, 2009; Bai *et al.*, 2010c). Regional methodologies can broadly be grouped into heuristic, inventory-based, statistical and deterministic approaches (Soeters, Van Westen, 1996; Aleotti, Chowdhury, 1999; Guzzetti, 1999; Van Westen *et al.*, 2006). Deterministic models are based on the laws of physics and generally apply simulations of water flow on slopes and a calculation of slope stability with geotechnical equations. The most frequently applied regional deterministic models are one-dimensional, such as the infinite slope stability model (Hammond *et al.*, 1992; Montgomery, Dietrich, 1994; Wu, Sidle, 1995, 1997; Sidle, Wu, 1999). These approaches are based on the concept of topographically induced wetness initially proposed by Beven and Kirkby (1979). The simplicity of the infinite slope model makes it possible to compute slope stability in GIS.

One such model is SINMAP (Stability Index Mapping), which allows for a relatively quick analysis of landslide susceptibility over large areas even with limited data availability (Pack *et al.*, 1998, 2001, 2005). SINMAP has been successfully applied by many landslide researchers and practitioners, and the majority reported satisfying modelling results with high proportions of known landslides being located in the areas modelled as most susceptible (Morrissey *et al.*, 2001; Zaitchik *et al.*, 2003; Zaitchik, Van Es, 2003; Meisina, Scarabelli, 2007; Thiebes *et al.*, 2007; Weerasinghe *et al.*, 2007). Some authors reported over-prediction of landslide susceptibility (Morrissey *et al.*, 2001; Meisina, Scarabelli, 2007). A number of researchers chose to combine SINMAP simulations with additional analyses, including statistical methods (Zaitchik *et al.*, 2003), calculations of certainty factors (Lan *et al.*, 2004) and the application of the most likely landslide initiation point method (MLIP) (Tarolli, Tarboton, 2006). Legorreta Paulin *et al.* (2010) compared SINMAP to a multiple logistic regression model and found that SINMAP was less affected by pixel resolution, with relatively constant results for 1 m, 5m, and 10 m pixels. However, with 30 m pixels, SINMAP predictions were inefficient for small and shallow landslides. Comparisons of SINMAP with similar deterministic slope stability models have been presented by Meisina and Scarabelli (2007) for SHALSTAB, and Morissey *et al.* (2001) for LISA and Iverson's Transient Response Model. The majority of SINMAP applications concentrated on shallow translational slides; however, in some works other processes such as debris flows (Morrissey *et al.*, 2001) and deep-seated landslides (Kreja, Terhorst 2005, 2009; Legorreta Paulin *et al.* 2010) have been included. Despite the large number of published SINMAP studies, no complete sensitivity analysis of all involved parameters has been reported yet. However, such information would be highly desirable for future SINMAP applications to be able to focus investigations on the most effective parameters and to achieve more reliable modelling results. Moreover, some of the results of partial sensitivity analyses contradict each other; Zaitchik *et al.* (2003) reported a relative low sensitivity to the cohesion factor and to soil thickness, but a high sensitivity to internal frictions and transmissivity. In contrast, Meisina and Scarabelli (2007) detected a strong influence of cohesion factor on modelling results, and Morrissey *et al.* (2001) described rainfall as one of the most influential factors.

In this paper, the application of the physically-based landslide model SINMAP to two study areas with different geo-environmental conditions is presented. The first study area is located in the Swabian Alb in south-west Germany, the second in the Youfang catchment, Wudu region in China's western Province Gansu. SINMAP was applied to both study sites in order to assess the regional landslide susceptibility and to evaluate the ability of the model for the delineation of spatial landslide probability. Besides the comparison of modelling results between the two study areas, a sensitivity analysis of the involved geotechnical parameters was carried out which has not been described in the literature yet.

2. STUDY AREAS

2.1. Swabian Alb

The first study area of this research is located in the Swabian Alb, a mountain range in southwest Germany (Fig. 1). The lithology of the Swabian Alb consists primarily of Jurassic clay underlying marl and limestone strata, of which the latter form a steep escarpment which stretches in a southwest-northeast direction for some 200 km. Elevations reach up to 1,000 m.a.s.l. in the western part, and range between 600 and 800 m.a.s.l. in the central and eastern sections, respectively. Landslides are a common geomorphological feature in the region due to lithological conditions (Terhorst, 1997) and triggering impact of rainfall events, snow melting and earthquakes (Meyenfeld, 2009). In total, approximately 30,000 landslide bodies of various sizes and ages can be assumed for the entire Swabian Alb (Bell, 2007). The most recent large landslide event was the Mössingen rockslide that took place in 1983. During this event, approximately 6 million cubic meters of material were triggered by exceptionally wet conditions (Fundinger, 1985; Bibus, 1986; Schädel, Stober, 1988). Several authors emphasise the importance of landslides for the relocation of the cuesta escarpment and the evolution to the present landscape (Bleich, 1960; Terhorst, 1997; Bibus, 1999), but landslides also represent a significant geo-hazard at present (Kallinich, 1999; Kreja, Terhorst, 2005; Bell, 2007; Neuhäuser, Terhorst, 2007; Papathoma-Köhle *et al.*, 2007; Terhorst, Kreja, 2009; Thiebes, 2012).

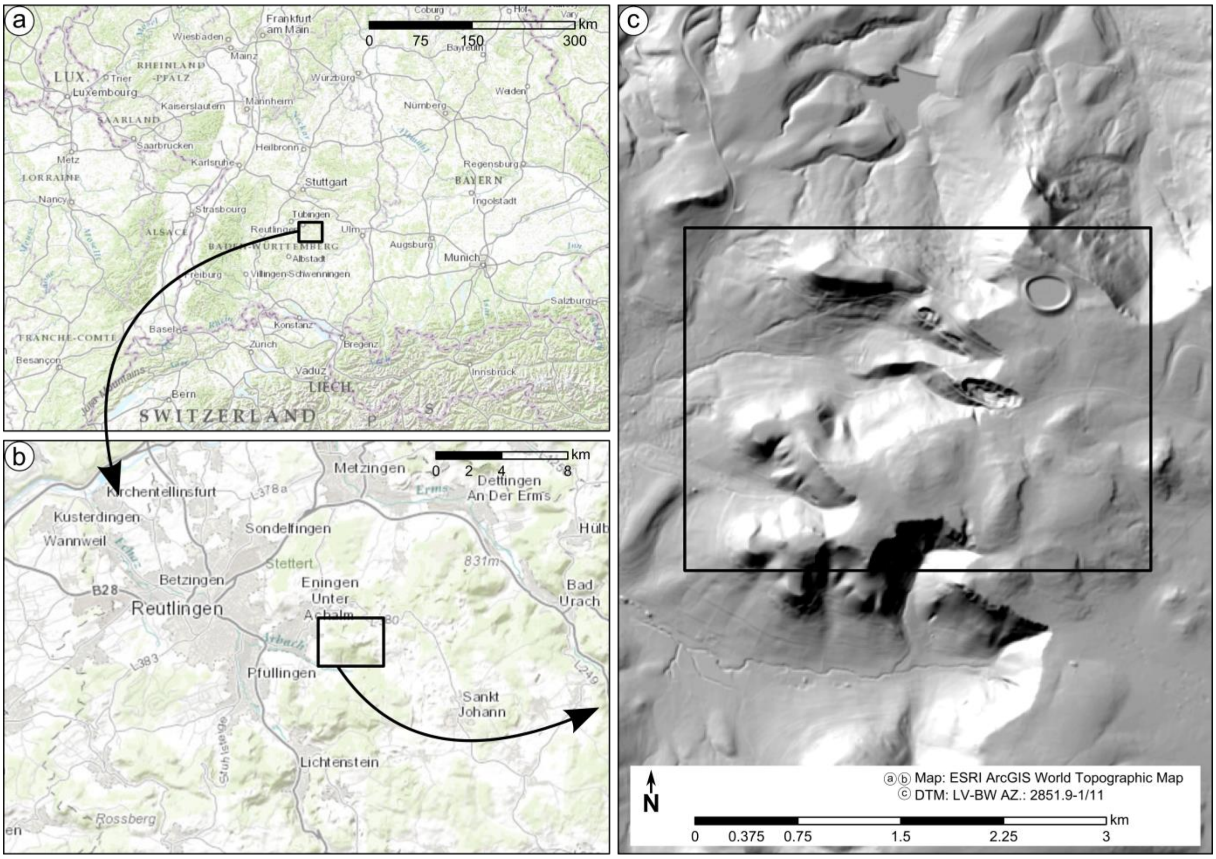

Fig. 1 – The study area Eningen in the Swabian Alb. Please note that the circular shape in the north-eastern corner of the study area is a reservoir of a hydro-electricity plant.

The main study area, for which susceptibility mapping was carried out, covers 8.5 km² and is located in Eningen, a small town east of Reutlingen. Elevations in the study area range between 500 m and 750 m a.m.s.l. The lithology includes Upper Jurassic limestone and marl strata which are slightly dipped into a south-west direction by 1 – 2° (Leser, 1982). The slopes are mostly covered by debris with a depth of 2 – 6 m (Ohmert *et al.*, 1988), which derives from Pleistocene solifluction and activity of shallow landslides. The study area includes parts of the relatively flat plateau area, the steep escarpment built by limestone (*Albtrauf*), and lower slopes consisting of Middle Jurassic marls and clays. The steep slopes are covered by forests, while the lower slopes and the plateau are used as grass-and-farmland. The mean annual precipitation for the closest weather station is 942 mm, however, climatic conditions are strongly influenced by orographic effects. Given the small size of the study area Eningen, and the availability of highly detailed light detection and ranging (LiDAR) topography, landslide mapping was carried out by a desk-based study of the digital terrain model (DTM) and its derivates (e.g. hillshades, slope map), as well as by field investigations in which the mapped landslides were validated and additional landslides were recorded. In total, 141 shallow landslides were mapped which add up to an area of 0.14 km², or 1.7% of the study area. The majority of shallow landslides occur on steep slope segments and in topographic hollows. More than 70% of the landslides are smaller than 1,000 m². These slope failures generally have a depth of less than 2 m and do not involve the bedrock. Larger landslides, in some cases covering more than 2,500 m² make up more than 70% of the landslide-affected areas in the study area. These slope failures are mostly complex landslides involving translational movements in the upper part and a flow-like run-out. In addition to the aforementioned slope failures, even larger mass movements are present in the study area. These are large rotational failures which transition into flow movements in the lower parts. However, these landslides were excluded from this study.

2.2. Youfang

The second study area is Youfang catchment located in Beiyuhe basin in Wudu county, Longnan prefecture, in southern Gansu Province, north-western China (Fig. 2). This region is surrounded by the Qinghai-Tibet Plateau to the West, the Loess Plateau to the North, and the Sichuan Basin to the South. Wudu region features steep slopes reaching maximum elevations of more than 3,500 m a.m.s.l. while valley floors are as low as 1,000 m a.m.s.l. The V-shaped valleys are deeply incised and accommodate fast-flowing rivers. The steep slopes of this rural region are often terraced and are used for agriculture. The lithology of the study area includes a variety of strata among which Devonian and Silurian phyllites, slates and schists, as well as loess deposits which are known for a high landslide susceptibility (Li 1997). The area features a high tectonic activity with frequent earthquakes due to the uplift of the Qinghai-Tibet plateau. The region has a semi-arid, monsoon-influenced climate with cold winters and hot and moderately humid summers. Mean annual rainfall is influenced by the orographic effects of the high mountains and totals between 400 mm and 900 mm (Chen *et al.*, 2006). Approximately 80% of the annual rainfall is recorded between May and September with maximum hourly and daily precipitation as high as 40 mm and 90 mm, respectively. The combination of steep topography, weak lithologic formations and the high activity of triggering events make Wudu region one of the most landslide-prone areas in China (Scheidegger, Ai, 1987), and consequently, several landslide-related investigations have been carried out (Chen, 2004; Bai *et al.*, 2009, 2010a, 2010b, 2012). Landslides represent an important geo-hazard in the region and significant damage has been reported. For example, a single rainfall event on August 3, 1984 triggered more than 400 debris flows and 570 landslides which affected approximately 9.3 million people and caused a direct economic loss of 265 million RMB (approximately US-$ 42 million) (Chen *et al.*, 2006). In total, at least 567 people were killed by landslides in the past four decades (China Geological Survey Bureau of Statistics, 2008). The most recent example of the catastrophic effects of landslides in Southern Gansu was a debris flow in Zhouqu which occurred on August 8, 2010. A localised rainfall event triggered this fast-moving debris flow which swept through the city and destroyed large areas claiming at least 1,287 lives (Yu *et al.*, 2010). Earthquakes are another important landslide triggering agent and over the past decades seismic-triggered landslides often blocked rivers by landslide dams (Chen, 2004). A recent study on the influence of environmental factors concluded that in particular lithology, aspect, elevation, and distance to rivers and to faults strongly influence the spatial distribution of landslide (Bai *et al.*, 2012). Moreover, the on-going urbanisation of the area, and the reconstruction works following the Wenchuan earthquake in 2008 have increased the impacts of landslide occurrences on society (Chen *et al.*, 2006).

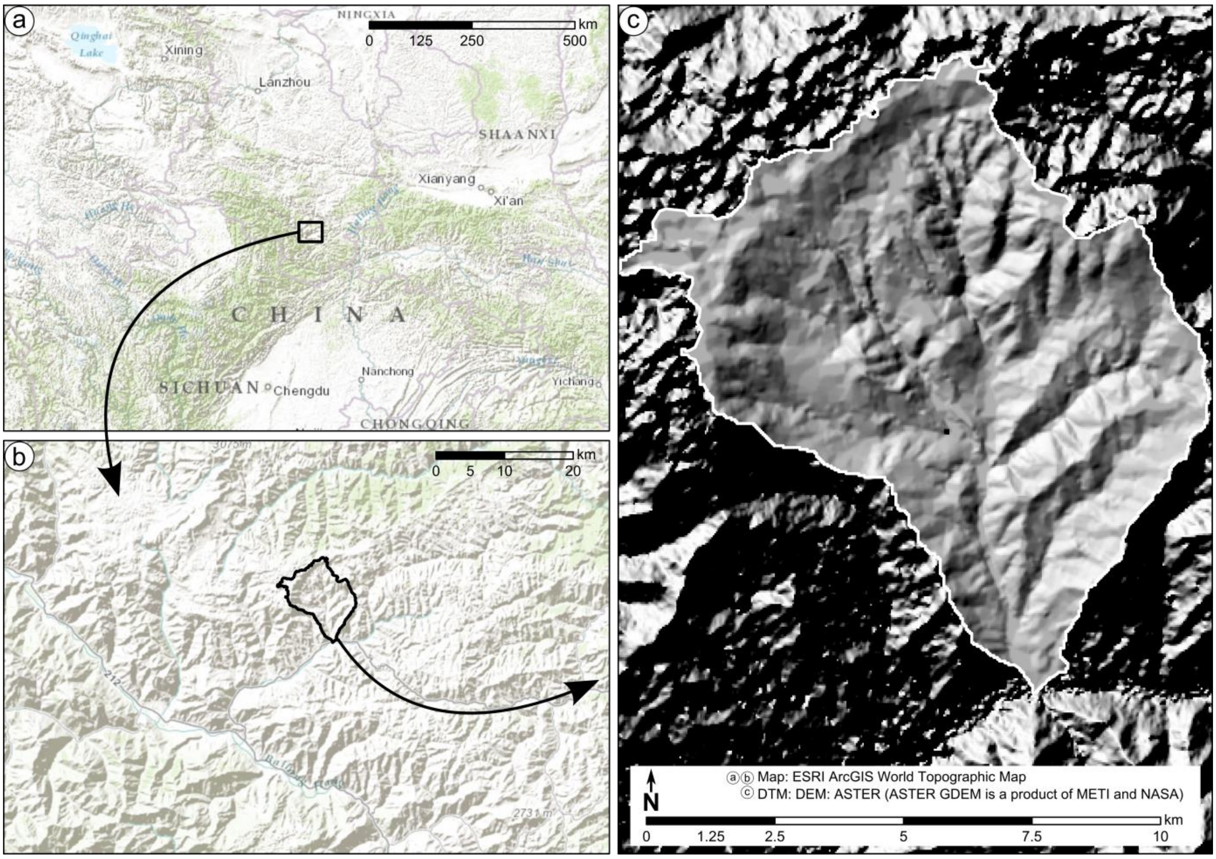

Fig. 2 – The study area Youfang catchment in southern Gansu Province.

The Chinese study area in which SINMAP was applied is Youfang catchment which covers 47.5 km² and is located approximately 15 km north-east of the provincial capital Longnan. Due to the size and remote location of the Youfang study area, as well as the non-availability of highly detailed topographic data, landslide mapping could not be carried out in the same way as for the German study area. Instead, a landslide inventory based on the interpretation of optical remote sensing data and provided by the Chinese Geological Survey in which rainfall-triggered landslides that occurred between 1995 and 2003 were recorded, was used. Field investigations and additional validation by optical remote sensing data revealed that the areas mapped as landslides rather cover landslide affected areas then single landslide bodies; several landslides as well as non-affected areas were combined within single polygons. Improvements of the available inventory proved to be extremely difficult since agricultural activities, in particular terracing, quickly lead to destruction of geomorphological evidence of landslides. Consequently, the inventory was used in its original form. In total, 65 landslides were mapped which in total cover approximately 14% of the study area. The landslide inventory is classified according to the Chinese system and includes rock, colluvial and loess landslides. Within the international landslide classification by Cruden and Varnes (1996), the landslides can be defined complex slope failures including primarily translational and to a minor extent also rotational slides of regolith which in some cases exhibit a flow type run-out. The landslides in Youfang catchment developed within highly permeable materials such as colluvial slope debris of Pleistocene age, and loess deposits which are located above relatively impermeable bedrock. As Youfang catchment is heavily used for agriculture and terracing of slopes is very common practice, almost all landslides took place on slopes which have been significantly altered by human modification. Landslides in the study area are mostly located in topographic hollows, which hints the influence of water convergence on landslide initiation. The landslides greatly vary in size, with small landslides from a few hundred or thousand m² up to the largest; which according to the inventory; cover areas of up to 250,000 m².

3. METHODS AND DATA

3.1. SINMAP model

SINMAP is a physically-based software relying on the infinite slope stability model that is available free of cost as an extension to ESRI ArcView 3 and ArcGIS 9. The model was developed by Pack *et al.* (1998, 2001, 2005) to carry out regional susceptibility assessments of translational landslides in British Colombia. A brief introduction to SINMAP's theoretical background is provided below, more detailed explanations can be found in the technical handbooks (Pack *et al.*, 1998, 2005).

SINMAP couples the infinite slope stability model and a steady-state topographic hydrologic model. A basic assumption of the infinite slope model is that a permeable soil layer parallel to the ground surface overlies an impermeable layer such as bedrock. The contact zone between the layers is considered the shear surface for potential slope failures. Shallow subsurface water flow is simulated following the topographic gradient and deep drainage is neglected. Higher saturation develops in concave slope areas and reduces internal friction and cohesion which leads to decreased slope stability.

The basic stability calculation within SINMAP is described by

$$FoS = \frac{C + \cos\theta[1 - wr]\tan\phi}{\sin\theta} \tag{1}$$

where *FoS* is the Factor of Safety; *C* is the dimensionless cohesion value integrating both soil and root cohesion, as well as soil density and thickness; θ is the slope angle; *w* is the relative wetness as the relation of water-table height to soil thickness; *r* is the constant soil density ratio; ϕ is the internal friction angle. Relative wetness (*w*) is modelled as induced by topographic conditions and depends on the specific catchment (*a*) area of a given point (Tarboton, 1997), the effective water recharge I for a critical period of wet weather and the soil transmissivity (*T*), i.e. hydraulic conductivity times soil thickness. In SINMAP, *T/R* is used as an input parameter rather than *R/T* because it can be interpreted as the length of a straight slope required to reach saturation. To define the stability of an area, the wetness index *w* is incorporated into the dimensionless Factor of Safety equation

$$FoS = \frac{C + \cos\theta\left[1 - min\left(\frac{R}{T}\frac{a}{\sin\theta}, 1\right)r\right]\tan\phi}{\sin\theta} \tag{2}$$

The specific catchment area (*a*) and the slope angle are derived from the DTM topography, while cohesion (*C*), internal friction (ϕ) and the combined factor *R/T* are soil-hydrological parameters.

In SINMAP's slope stability calculation, parameter uncertainty for the last three parameters is incorporated and uniform probability distributions between given minimum and maximum values are assumed. Areas for which the worst case parameter constellations result in a *FoS* of greater than 1 are considered unconditionally stable. For all other areas, there is a probability of failure that is expressed as the Stability Index (*SI*). When even the best case parameter constellations result in a *FoS* of less than 1, a *SI* of 0 is assigned. These areas are considered unconditionally unstable (*defended*). In total, SINMAP differentiates six *SI* classes. *Stable*, *moderately-stable* and *quasi-stable* classes have a minimum *SI* greater than 1 and represent regions that should not fail with the most conservative parameters in the specified range. For these areas, external destabilising factors would be required to cause instability. For the *lower*-and-*upper-threshold* classes the calculated *SI* is smaller than 1, and the probability of failure is less than or greater than 50%, respectively. For *lower-threshold* areas, no external destabilising factors are required for instability; for *upper-threshold* areas stabilising factors might be responsible for stability.

3.2. Base data

SINMAP requires three essential types of input data to perform the stability calculation: topographic data as a grid-based DTM, maps displaying the spatial distribution of surface material (calibration areas), e.g. lithology, and their respective geotechnical properties, and an inventory of past landslide occurrences. An overview on the base data used in this study is presented in Table 1.

Table 1

Input data used within the study

Type	**Comment**	**Resolution**	**Source**
Swabian Alb			
DTM	Airborne LiDAR data	1 m x 1m	STATE OFFICE OF LAND SURVEY (LVBW)
Geological map	Map sheet 7,520 Reutlingen	1:50000	STATE OFFICE OF GEOLOGY, RESOURCES AND MINING (LGRB)
Land use map	Only forest was considered	1:25000	STATE OFFICE OF LAND SURVEY (LVBW)
Geotechnical parameters	Literature values	–	MEYENFELD (personal communication)
Landslide inventory	Mapping	Polygons	LiDAR and field mapping
Youfang			
DTM	Digitised from 1:50000 topographic map	30 m x 30 m	NATIONAL ADMINISTRATION OF SURVEYING, MAPPING AND GEOINFORMATION
Geological map	Lithological classes combined based on geomechanical characteristics	1:200000	CHINA GEOLOGICAL SURVEY; WU & WANG (2006)
Geotechnical parameters	Laboratory testing	–	WU & WANG (2006)
Landslide inventory	Mapping from optical remote sensing data	Polygons	CHINESE GEOLOGICAL SURVEY

LVBW = Landesvermessungsamt Baden-Württemberg; LGRB = Landesamt für Geologie, Rohstoffe und Bergbau Baden-Württemberg

3.2.1. Swabian Alb

For the study area in the Swabian Alb, a LiDAR-based DTM with a 1m-scale was available. For the SINMAP simulations, the spatial scale was decreased to 10 m by the ArcGIS ‘resample’ function using the nearest neighbour algorithm. Another DTM with 30 m pixels was created to allow for an easier comparison of results to the study area in China. A geological map (1:50000) was used to describe the spatial distribution of surface materials. In this study, it was not possible to assess the geotechnical parameters for the respective lithological units by laboratory analyses, and instead a database of geotechnical values extracted from literature sources (Meyenfeld, personal communication) was used. The determination of the cohesion and friction angle values was relatively straightforward due to the availability of several laboratory tests with similar materials published in the literature. The soil-hydrological factor *T/R*, however, could not easily be assigned based on literature values because it is only used in SINMAP. Therefore, the default values of *T/R* (Pack *et al.*, 1998, 2001; Pack & Tarboton 2004; Pack *et al.*, 2005) were used and modified for the lithology classes in the study area: for clayey materials, the minimum *T/R* values were decreased for up to 1,000 units to meet the water retaining characteristics; for more permeable materials, the value was increased for up to 250 units. In addition, the calibration tool implemented in SINMAP (i.e. SA plots) was used to define more appropriate parameter values. Thereto, modelling is repeated using modified parameter values until a satisfactory proportion of landslides was computed in areas of low stability. To be able to carry out a comparable sensitivity analysis, the range between the lower and the upper bounds of the geotechnical parameters for friction angle and *T/R* were chosen to be the same for all geotechnical classes. For friction angles, a difference of 10° was chosen, and for the hydrological parameter *T/R* a range of 1,000 units between minimum and maximum values was selected. Thereby, the selected ranges are the same as described in the SINMAP handbook. The stabilising influence of vegetation on slope stability was also included for the Swabian Alb case study. The spatial distribution of forests in the study area was extracted from a digital land-use map (1:25000) and merged with the geology map. For all areas covered with forest, the upper bound of cohesion was increased by 10 KN/m^2, which is similar to the values used in other studies (Hammond *et al.*, 1992; Sidle, Wu 1999; Sidle, Wu 1999). Given the fact that the determination of geotechnical parameters involved significant subjective input, the chosen values were subsequently calibrated by repeated SINMAP simulations and an analysis of the results. The landslide inventory derived from desk- and field-based analyses was converted to a raster data-set with a spatial resolution equivalent to the DTM using the ‘maximum area function’ of the ArcGIS ‘polygon to raster’ tool: each pixel of the raster map is assigned the value of the feature (landslide or non-landslide) that fills the greater part of that specific pixel. Thereby, the rasterised landslide map can exclude areas within the original landslide boundaries, or include areas formerly outside the boundary.

3.2.2. Youfang

For the study area in Youfang catchment, a 1:50000 topographic map was available; the contour lines were digitised and transformed to DTM with 30 m grid resolution using the ‘Topo to raster’ function in ArcGIS. Information on the spatial distribution of surface materials was available in the form of a geological map (1:200,000) produced by the China Geological Survey. Unfortunately larger-scale maps of the study area are not available for research purposes. It is important to note that the Geological map does not describe any loess in the study area even though field evidence confirms the presence of loess deposits. The aforementioned map had been aggregated by Wu and Wang (2006) based on the geomechanical characteristics of the respective lithological classes. For the displayed units, the geotechnical parameters cohesion and friction angle were determined from the values provided by Wu and Wang (2006), who carried out laboratory tests of material properties in a study area close to Youfang catchment. The *T/R* values were assigned in the same way as in the German study area, i.e. by modifications of the default values by subjective interpretation, as well as calibration, using the SINMAP SA plots. No information on vegetation cover was readily available and consequently the strengthening effect of root cohesion was not taken into account. The landslide inventory provided by the Chinese Geological Survey in which the boundaries of landslide-affected areas were mapped was transferred to a raster map in the same way as for the German study area.

3.3. Application of SINMAP

In this study, the SINMAP version developed for ArcView 3 was used to run the model because the newer version for ArcGIS 9 produced error messages. According to one of the SINMAP developers, this is caused by some bugs related to the conversion of SINMAP from ArcView 3 into ArcGIS 9 (Tarboton, personal communication). The results of the SINMAP simulations, i.e. the stability index maps, were exported and analysed in ArcGIS 9. Parameter settings were calibrated by repeated simulation runs with slightly different parameter settings, as well as by using the in-build calibration tools (SA plots). The resulting maps were evaluated based on their agreement with the spatial landslide distributions (proportion of landslides captured within highly susceptible areas), as well as their geomorphological quality. Quality assessment of a SINMAP simulation traditionally uses point data describing landslide locations. However, in this study landslide data were available as polygon data describing the entire spatial extent of slope failures. Therefore, it was decided to include the entire landslide-affected area for the assessment of SINMAP modelling results. The ‘raster calculator’ tool in ArcGIS was used to create grids in which only the landslide-affected stability classes are displayed which then could be used for a statistical analysis. *No data* areas are primarily caused by the hydrological simulations by SINMAP; for each cell of the DTM the flow direction and the specific catchment area is calculated. Cells for which no specific catchment area can be calculated, e.g. the uppermost cells, are assigned the *no data* value.

3.4. Sensitivity analysis

A sensitivity analysis of the model input parameters cohesion, internal friction and the hydro-geological parameter *T/R* was carried out to assess their influence on SINMAP slope stability calculation. The initially determined minimum and maximum values assigned to the lithological classes, referred to the following as ‘standard values’, where manually modified in 10%-steps in the range between 50% and 150% of the standard values. This range was selected because it was considered to cover the realistic possible range of the real parameter values. During the sensitivity analyses, only one parameter’s minimum and maximum values were adjusted at a time, while all the other parameters were kept at their original value. Then, the model simulation was repeated and the resulting maps were analysed for the distribution of the stability classes. For cohesion, this procedure was not possible because the standard value for the minimum cohesion was set to zero to allow for completely saturated conditions in which no soil cohesion is present. Therefore, only the upper bound of cohesion (C_{max}) was treated in the same way as described above, and the lower cohesion bound (C_{min}) remained zero. In a last step all parameters except for C_{min} were kept at their standard values and only C_{min} was raised to the standard value of C_{max} (100% scenario) and then gradually decreased in 10% steps to its original value (0% scenario). The sensitivity analysis was carried out with 10m-and-30m-scale for the study area in the Swabian Alb, and with 30 m data for the study area in Youfang.

4. RESULTS

4.1. Input data

4.1.1. Swabian Alb

The geological map scaled 1:50000 displays a total of 20 classes from Middle and Upper Jurassic, and the Quaternary and Tertiary. Table 2 lists the classes and their geotechnical parameter values for the standard scenarios (100% parameter values). The combination with the forest distribution from the land-use map (1:25000), the combination of classes with the same geotechnical parameter values and the aggregation of classes with only small spatial extents during the following conversion to a 10 m raster resulted in a total of 23 classes based on lithology and vegetation. The change of spatial resolution to 30 m reduced the total number of classes to 14. In addition, the representation of the topography changed with an altered pixel resolution; steep areas occur less often and small topographic hollows, important for flow convergence, are often levelled out. Additional effects could be observed for the landslide inventory; the areas affected by landslides slightly decreased from the original inventory to the 1 m and the 30 m DTM.

Table 2

Geotechnical parameter values for the classes of the Geological map (1:50000) for the Swabian Alb. Descriptions are based on Ohmert *et al.*, 1988; Geyer, Gwinner, 1986; Wagenplast, 2005; and Bell, 2007

	Class	**Description**	C_{min}	C_{max}	Φ_{min}	Φ_{max}	T/R_{min}	T/R_{max}
Quaternary and Tertiary	Floodplain sediments	–	0	0.3	20	30	1,500	2,500
	Calcerous sinter	–	0	0.2	25	35	2,250	3,250
	Loess sediments	–	0	0.3	20	30	1,750	2,750
	Colluvium	–	0	0.25	20	30	2,000	3,000
	Slope debris	solifluction and landslide activity	0	0.15	25	35	2,000	3,000
	Basalt tuff	volcanic activity in Miocene	0	0.15	15	25	2,000	3,000
	Xenolith in basalt tuff		0	0.15	15	25	2,000	3,000
Upper Jurassic	Zementmergel (ki5)	lime marls, marl lime and lime; partly massive	0	0.25	20	30	1,750	2,750
	Liegender Bankkalk (ki4)	alternating sequences of lime- and-marl lime separated by marl beds	0	0.2	25	35	2,250	3,250
	Unterer Massenkalk (joMu)	massive and compact limestone	0	0.2	20	30	2,250	3,250
	Unterer Massenkalk und Zuckerkorn-Dolomit Fazies (joMuZD)	cavernosus dolomite limestones	0	0.2	20	30	2,250	3,250
	Unterer Felsenkalk (ki2)	dominantly massive lime; partly layered limestone beds	0	0.2	20	30	2,250	3,250
	Lacunosamergel (ki1)	marl limestone with varying clay content	0	0.25	20	35	1,750	2,750
	Wohlgeschichter Kalk (ox2)	uniformly stratified limestone with thin marl beds; partly massive	0	0.2	23	33	2,250	3,250
	Impressamergel (ox1)	alternation of marl and marl lime beds	0	0.25	20	35	1,750	2,750
Middle Jurassic	Ornatenton (cl)	clay stones with oolitic iron horizons	0	0.3	20	30	1,000	2,000
	Dentalienton (bt)	clay stones with interstratified marl lime beds	0	0.25	20	30	1,000	2,000
	Hamitenton (bj3)	dominantly clay stones	0	0.25	20	30	1,000	2,000
	Ostreenkalk (bj2)	plastic clays and clay marls, inter-stratified marl lime beds	0	0.25	25	30	1,750	2,750
	Blaukalk (BL)	marl and dolomite limestone	0	0.25	25	35	2,250	3,250

The assigned parameter values for C_{min} are 0 for all classes. C_{max} ranges between 0.15 KN/m² for unconsolidated slope debris and reaches a maximum of 0.3 KN/m² for the claystones of the *Ornatenton*. The lowest friction angles were assigned to the basalts for which the lower and upper bounds were set to 15° and 25°, respectively; the highest values are related to slope debris and *Blaukalk* for which the lower and upper bounds are 25° and 35°, respectively. Minimum values for *T/R* range from 1,000 for the clay rich materials of the Middle Jurassic, and the highest value of 2,250 was assigned to the limestone areas which are assumed to be influenced by karst processes.

4.1.2. Youfang

The aggregated geological map for Youfang catchment displays three lithology units in the study area. These include phyllites, sand- and-mudstones, and limestones and slates (Table 3). With respect to the laboratory analyses by WU & WANG (2006), the lowest friction angle in combination with medium cohesion values was assigned to phyllites. For *T/R*, the standard values from SINMAP were used. The lowest cohesion and highest friction angle values were assigned to the class of sandstones and mudstones. Relatively low *T/R* values were chosen because a low permeability was assumed. The highest *T/R* and cohesion values were added to the limestones and slates which have been described as relatively compact and not affected by karst processes.

Table 3

Geotechnical parameter values for the classes of the Geological map (1:200000) for Youfang catchment

Class	**Description**	C_{min}	C_{max}	Φ_{min}	Φ_{max}	T/R_{min}	T/R_{max}
Phyllite	Mostly phyllites; some quartzites, sericite tuff, carbonaceous phyllite, slate, limestone, chert and fine siltstone	0	0.25	15	25	2,000	3,000
Sandstone/Mudstone	Mud-and-siltstone, silty mudstone and muddy siltstone and sandstone, conglomerates	0	0.2	25	35	1,000	2,000
Limestone/Slate	Thick layer of limestones and slates, some phyllites, chert, silty and fine sand	0	0.3	20	30	2,500	3,500

4.2. Modelling results

4.2.1. Swabian Alb

Within the statistical analysis of SINMAP simulations, several features can be investigated. The most obvious aspect to analyse is the percentage of each stability class in the study area. Here, *no data* areas can be included or excluded. Similarly, the percentage of landslides in the stability classes can either be evaluated only for areas for which a stability index has been modelled, but also for *no data* areas. Finally, the degree to which the stability classes are affected by landslides can be quantified.

The susceptibility modelling with the 10 m data resulted in a very high proportion (56.3%) of the study area being classified as *stable* (Fig. 3A and Table 4). This class includes primarily the relatively flat areas of the plateau and some parts of the valley floor. The medium susceptibility classes *moderately-stable* and *quasi-stable* are present in the transition zone between *stable* areas and higher susceptibility classes. However, together they only make up approximately 11.7% of the study area. In steep and convergent slope sections, the *lower threshold* and the *upper threshold* are dominant. In total, 31.8% were classified with the respective stability classes. The proportion of areas classified as *defended* is very low (0.2%). This stability class is only present on some extremely steep sections of the limestone escarpment. When *no data* areas are included in the analysis, the respective numbers are slightly lower. In total, *no data* areas cover 7.6% of the study area.

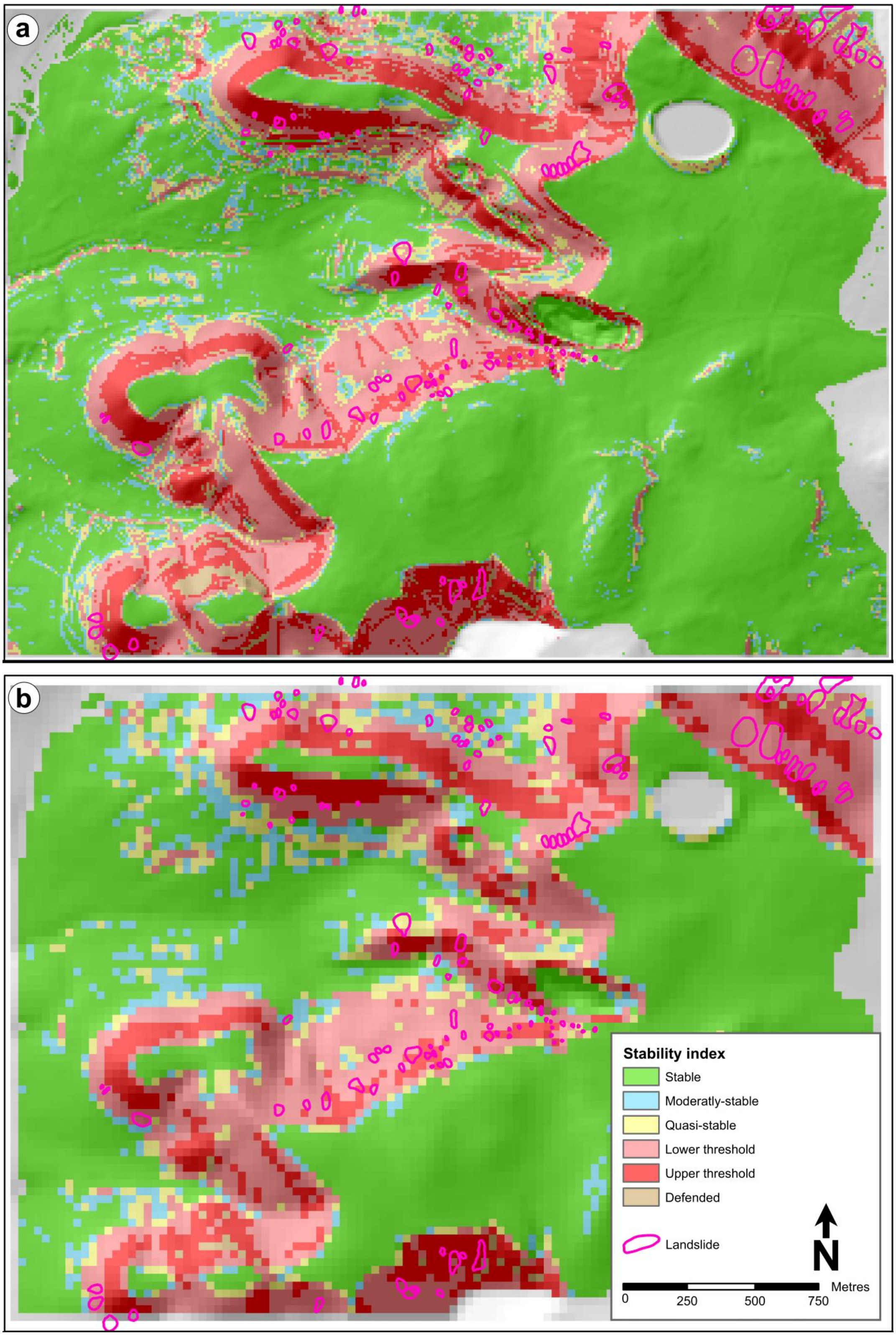

Fig. 3 – Landslide susceptibility maps for the study area in the Swabian Alb with (A) 10 m and (B) 30 m scale.

Table 4

Statistical summary of SINMAP modelling in the Swabian Alb study area

	10 m data set					30 m data set				
	Share of stability classes (in %)		**Share of landslides (in %)**		**Share of stability classes affected by landslides (in %)**	**Share of stability classes (in %)**		**Share of landslides (in %)**		**Share of stability classes affected by landslides (in%)**
	incl. *no data* area	excl. *no data* areas	incl. *no data* areas	excl. *no data* areas		incl. *no data* areas	excl. *no data* area	incl. *no data* areas	excl. *no data* areas	
Stable	52.0	56.3	2.1	2.2	0.1	48.9	55.5	2.1	2.3	0.1
Moderately-stable	5.0	5.4	3.5	3.6	1.0	5.8	6.6	2.7	3.1	0.7
Quasi-stable	5.8	6.3	8.1	8.5	2.1	5.6	6.4	11.6	13.1	3.2
Lower thresholds	22.0	23.8	65.9	68.7	4.5	18.3	20.8	57.5	64.6	4.9
Upper thresholds	7.4	8.0	16.0	16.6	3.2	9.1	10.3	15.1	16.9	2.6
Defended	0.2	0.2	0.3	0.3	2.2	0.4	0.4	0.0	0.0	0.0
No data	7.6	–	4.0	–	0.8	11.9	–	11.0	–	1.4

The vast majority (85.3%) of landslide-affected areas are either in the *upper* or the *lower threshold* classes. In particular, the *lower-threshold* areas accommodate a large proportion of landslide-affected areas (65.9%). However, it is important to take into account that the entire landslide-affected area was used which, therefore, also includes run-out areas. However, the landslide initiation zones are often located within, or close to, areas classified as *upper threshold*. Relatively low proportions of landslide are located in the more stable stability classes. *Moderately*-and-*quasi-stable* areas include 3.6% and 8.5% of the landslide-affected areas, respectively, while *stable* areas account for only 2.2%. Again, the numbers are slightly different when *no data* areas are included in the analysis. A total of 4% of the landslide-affected areas are within such areas.

When the degree to which the respective stability classes are affected by landslides is analysed, the highest proportion can be found for *lower* and *upper-threshold* classes, with 4.5% and 3.2%, respectively. Only 0.1% of the areas modelled as *stable* are affected by landslides even though this stability class is by far the most abundant.

The SINMAP simulation using the 30 m input data resulted in a similar susceptibility map with a high proportion (55.5%) of *stable* areas in the relatively flat parts of the study area (Fig. 3B and Table 4). *Moderately*-and-*quasi-stable* areas account for approximately 6.5% each, and are again mainly located in the transition zones between higher and lower stability classes. *Upper*-and-*lower threshold* areas are located on the steeper slope sections and account for 10.3% and 20.8% of the study area, respectively. Similar to the 10 m simulation, the proportion of defended areas is very low (0.4%). In comparison to the 10 m data set, the 30 m simulation includes a higher proportion of *no data* areas (11.9%). Overall, the 30 m susceptibility map shows a similar result as the 10 m map. However, the latter resembles a much finer classification. Topographic hollows and small-scale topography such as rivers or pathways are nicely highlighted by higher susceptibility classes, whereas the 30 m map does not distinguish these features because these are not well represented in the coarser data set. Additional differences can be observed in the transition zones between *stable* areas and higher susceptibility classes; in the 10 m map, the lower threshold areas are often framed by *quasi-stable* and *moderately-stable* areas. This cannot be observed in the 30 m susceptibility map.

The comparison of landslide locations with susceptibility classification yielded similar results as for the 10 m simulation, with the largest proportion of landslides (81.5%) being located in the *upper*-and-*lower-threshold* areas. Again, the *lower-threshold* areas accommodate the largest share (64.6%) of landslide-affected areas. Classes of higher stability, i.e. *quasi-stable*, *moderately-stable* and *stable* have a relative low proportion of slope failures with 13.1%, 3.1% and 2.3%, respectively. These areas mostly include the run-out zones of the landslides, while the initiation zones are dominantly located in areas of lower stability, i.e. *lower* or *upper threshold*. When *no data* areas are also been taken into account, the share of landslides in each stability is slightly lower due to the fact that a total of 11% of all landslide-affected areas are within *no data* areas. The degree to which the stability classes are affected by landslides is very similar to the 10 m results.

4.2.2. Youfang catchment

The results of SINMAP susceptibility modelling are presented in Fig. 4 and Table 5. In contrast to the study area in the Swabian Alb, the proportion of *no data* areas is larger (total of 28.4%), owing to the hydrological simulations in SINMAP and the poorer quality of the DTM available for Youfang. SINMAP’s hydrological simulation step applies a flow routing algorithm. For the outmost pixels, as well as for grid cells for which no lower lying neighbour is available, the simulation cannot be carried out and the *no data* value is assigned. Similar to the previous simulations, the susceptibility map for Youfang dominantly shows lower stability classes for areas with steep slopes. However, since the topography in Youfang catchment is more extreme and fewer flat areas exist, the proportion of areas marked as *stable* is lower (14.1% if *no data* areas are excluded). *Moderately-stable* and *quasi-stable* areas account for approximately 4.5% and 10.1%, respectively. *Lower-threshold* areas cover approximately 43.3% and make up the largest part of the study area, and in particular large proportions of the slope areas. The *upper-threshold* class can primarily be found on the steepest slope sections and covers approximately 22.6%. Areas for which the calculated stability is always so low that stability cannot be calculated under the given parameter range (*defended*) can be found on several steep slopes and make up a total of 5.3% of the catchment. The percentage of the respective stability classes is about one third lower when *no data* areas are included in the analysis (see Table 5).

The three highest susceptibility classes in the Youfang study area, i.e. *defended*, *upper* and *lower threshold*, include approximately 67.5% of all the landslide-affected areas, and each class accounts for 2.5%, 17.7% and 47.3%, respectively. *Quasi-stable* areas contain 13.9% of the landslide-affected areas, and *moderately-stable* areas approximately 5.6%. The proportion of landslide-affected areas in the *stable* class is relatively high and totals approximately 12.9%. The previously mentioned percentages refer to the results in which *no* data areas were excluded. If these are taken into account, a total of 31.4% of the landslides are located in areas for which no stability index could be calculated. In comparison to the German study site, all stability classes of the Chinese study site are much more affected by landslides with percentages ranging between a minimum of 6.1% for the *defended* class and a maximum of 17.6% for the *quasi-stable* class. In particular the latter is surprising given that only a relatively few share of the study has been classified with this stability class.

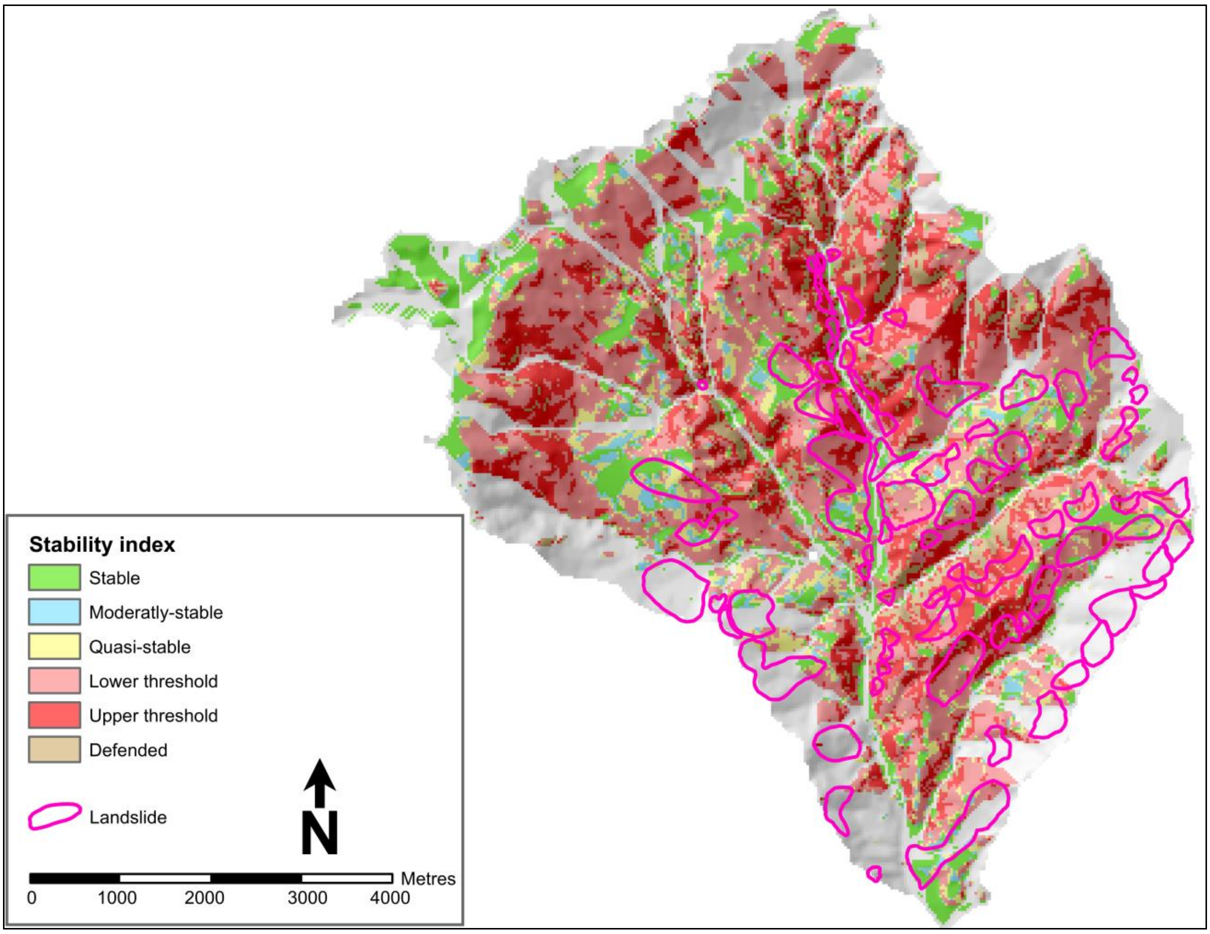

Fig. 4 – Landslide susceptibility map for the study area in Youfang study area with 30 m scale.

Table 5

Statistical summary of SINMAP modelling in the Wudu study area

	30 m data set				
	Share of stability classes (in %)		Share of landslides (in %)		Share of stability classes affected by landslides (in %)
	incl. *no data* areas	excl. *no data* areas	incl. *no data* areas	excl. *no data* areas	
Stable	10.1	14.1	8.9	12.9	11.8
Moderately-stable	3.2	4.5	3.9	5.6	16.0
Quasi-stable	7.2	10.1	9.5	13.9	17.6
Lower thresholds	31.0	43.3	32.4	47.3	14.0
Upper thresholds	16.2	22.6	12.2	17.7	10.1
Defended	3.8	5.3	1.7	2.5	6.1
No data	28.4	–	31.4	–	14.9

4.3. Sensitivity analysis

The results of the sensitivity analysis for the geotechnical parameters *Φ*, *T/R*, C_{min} and C_{max} are presented in Fig. 5. A visual interpretation of the sensitivity plots highlights the differences of SINMAP susceptibility classification between the study areas in the Swabian Alb and Wudu county. In contrast to the Swabian Alb, the fraction of *stable*, *quasi-stable* and *moderately-stable* areas is much lower in the Youfang case study. Approximately 50% of the study areas are classified with the three lowest stability classes when the standard parameters are used. On average, the proportion of *defended*, *upper*-and-*lower-threshold* classes in Youfang is approximately 4%, 6% and 10% higher, respectively. However, the interpretation of the differences between the modelling results of both study areas has to take into account that the fraction of *no data* areas differs significantly, and is almost 17% higher for Youfang than for the Swabian Alb simulation using the same spatial resolution of input data. Still, the general influence of single parameters on susceptibility modelling can be assessed and compared.

The comparison of the results of the sensitivity analysis for the Swabian Alb using 10 m and 30 m input data show similar results and trends for the influence of geotechnical parameters. Tables 6 and 7 give a detailed overview on the changes between these two maps by highlighting the differences of the susceptibility classification between the 10 m and 30 m maps. An increased proportion of *no data* areas can be observed, which was 7.6% for the 10 m data and 11.9% for the 30 m data. Also the fractions of *defended* and *lower-threshold* areas tend to be larger for the coarser input data. Small changes in both directions have been observed for *quasi-stable* and *moderately-stable* stability classes. The proportion of *upper-threshold* areas generally decreased for all parameters except for the friction angle, while the fraction of stable areas decreased with coarser input data for all tested parameters.

When comparing the influence of the four geotechnical parameters on susceptibility modelling, substantial differences can be observed. In particular the modification of the internal friction parameter led to drastic changes of the proportions of susceptibility classes. The adjustment of the parameter values between 50% and 150% of the standard values changed the proportion of *stable* areas for approximately 40% for the data set from the Swabian Alb. Higher friction angle values also decreased the fraction of the two most unstable classes which both only account for less than 1% for the highest friction angle parameter values. In Youfang catchment, the largest changes can be observed for the *defended*-and *upper-threshold* classes, for which the fractions decreases by 27% and 20%, respectively, when the friction angle is raised from 50% to 150% of the standard parameter. In addition, the percentage of *stable* areas increased for approximately 38%. In contrast to the friction angle, the modification of the hydrological parameter *T/R* resulted only in small changes of the susceptibility classification for both study areas and for both input data resolutions. The modification of *T/R* parameter values in the range of 50% and 150% of the standard values resulted in relatively small changes of approximately 2% on average. The largest changes (8.6%) can be observed for *stable* areas using the 30 m data in the Swabian Alb. The modification of maximum cohesion only caused changes of the three highest susceptibility classes. In comparison to the friction angle, the changes of susceptibility classification due to a modification of C_{max} are relatively small and average 3.5%. The largest changes can be observed for the *lower-threshold* class up to a maximum of 15% in the Youfang study area. A modification of the C_{min} factor has a larger influence on susceptibility modelling in comparison to C_{max}. On average, a change of approximately 8% can be observed. Pronounced differences can be observed for the *lower-threshold* class where a high C_{min} value changed the respective fraction by up to 23%.

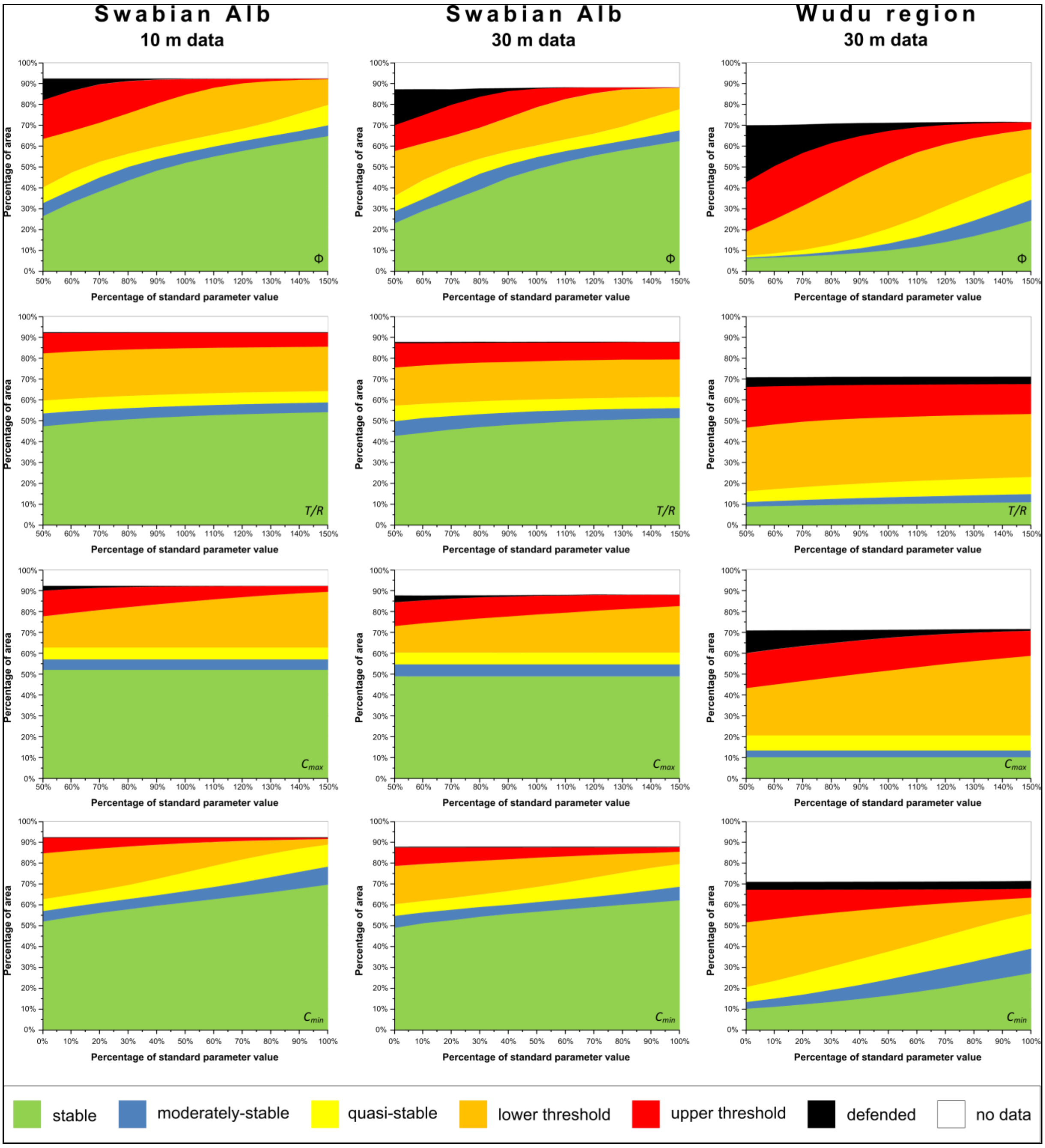

Fig. 5 – Sensitivity plots.

Table 6

Differences between the 10 m and 30 m sensitivity analysis for *T/R*, friction angle (*Φ*), and C_{max} for the Swabian Alb study area

		50%	60%	70%	80%	90%	100%	110%	120%	130%	140%	150%
T/R	no data	4.49	4.48	4.45	4.40	4.47	4.42	4.40	4.40	4.40	4.48	4.45
	stable	-4.40	-4.08	-3.76	-3.45	-3.27	-3.07	-2.83	-2.68	-2.64	-2.51	-2.59
	moderately-stable	0.97	1.13	0.94	0.86	0.83	0.82	0.55	0.44	0.37	0.14	0.12
	quasi-stable	1.24	0.70	0.52	0.25	0.15	-0.15	-0.13	-0.27	-0.24	-0.12	-0.11
	lower threshold	-4.42	-4.24	-3.95	-3.81	-3.90	-3.68	-3.54	-3.45	-3.33	-3.47	-3.40
	upper threshold	1.88	1.75	1.56	1.51	1.57	1.48	1.37	1.39	1.39	1.44	1.48
	defended	0.25	0.27	0.24	0.24	0.17	0.18	0.18	0.17	0.05	0.05	0.05
PHI	no data	5.20	5.13	5.18	4.75	4.63	4.42	4.23	4.29	4.27	4.28	4.27
	stable	-3.46	-3.99	-4.28	-4.40	-3.48	-3.07	-2.58	-2.25	-2.32	-2.42	-2.42
	moderately-stable	-0.54	-0.39	0.02	1.08	0.79	0.82	0.39	-0.13	-0.11	0.09	-0.03
	quasi-stable	-0.31	0.68	1.25	0.90	0.46	-0.15	-0.08	0.01	0.11	0.25	0.35
	lower threshold	-1.65	-2.34	-3.56	-4.62	-4.65	-3.68	-3.28	-2.52	-1.85	-2.27	-2.11
	upper threshold	-6.25	-5.74	-3.40	-0.49	1.36	1.48	1.27	0.64	-0.08	0.07	-0.06
	defended	7.01	6.65	4.78	2.77	0.89	0.18	0.06	-0.05	-0.03	-0.02	0.00
$\mathbf{C_{max}}$	no data	4.63	4.70	4.60	4.59	4.54	4.42	4.39	4.17	4.21	4.23	4.27
	stable	-3.02	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07	-3.07
	moderately-stable	0.79	0.82	0.82	0.82	0.81	0.82	0.81	0.82	0.82	0.82	0.82
	quasi-stable	-0.18	-0.15	-0.15	-0.15	-0.19	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15
	lower threshold	-2.26	-2.45	-2.80	-3.02	-3.40	-3.68	-4.04	-4.20	-4.39	-4.54	-4.46
	upper threshold	-1.01	-0.67	-0.13	0.41	0.95	1.48	1.89	2.26	2.50	2.68	2.59
	defended	1.06	0.83	0.73	0.43	0.36	0.18	0.18	0.18	0.08	0.04	0.00

Table 7

Differences between the 10 m and 30 m sensitivity analysis C_{min} for the Swabian Alb study area

		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
$\mathbf{C_{min}}$	no data	4.42	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41
	stable	-3.07	-3.00	-3.54	-3.61	-3.99	-4.48	-4.88	-5.46	-6.01	-6.82	-7.54
	moderately-stable	0.82	0.34	0.27	-0.17	-0.55	-0.71	-1.09	-1.42	-1.92	-2.02	-2.07
	quasi-stable	-0.15	-0.34	-0.51	-0.79	-1.22	-1.76	-2.06	-1.75	-1.08	-0.35	0.32
	lower threshold	-3.68	-3.31	-2.87	-2.23	-1.16	0.08	1.20	1.93	2.56	2.87	3.32
	upper threshold	1.48	1.71	2.05	2.21	2.33	2.30	2.28	2.15	1.91	1.77	1.48
	defended	0.18	0.18	0.18	0.17	0.17	0.16	0.15	0.14	0.13	0.13	0.07

5. DISCUSSION

The application of SINMAP to the two study areas located in Germany and China resulted in generally reasonable susceptibility classification of the terrain, although the environmental and geomorphological conditions, and also data quality vary strongly between the two sites. Whereas the Swabian Alb study site features relatively shallow landslide and is covered by highly detailed topographic data, the Youfang catchment in China is affected by larger slope instabilities, also including rotational landslides, and is represented by a relatively poor DTM. Nevertheless, SINMAP produced acceptable susceptibility maps due to the physically-based methodology used; steep areas, topographic hollows and other areas of flow convergence, which are dominantly affected by shallow landsliding, feature lower stability classes. Still, due to the great differences between both studies, making a direct comparison between the model results is not feasible.

For the Swabian Alb, a relatively large area has been modelled as *stable*, and only a very small proportion of these areas are affected by landslides. In total, more than 80% of the landslide-affected areas are located in the three highest susceptibility classes when using the 10 m data set, and even with the coarser data these classes contained more than 72% of the landslide-affected areas. The *lower* thresholds stability class was hereby most affected by landslides but is also the second most common class in the simulations.

For Youfang, the proportion of high susceptibility classes is higher than in the Swabian Alb, and only 10% to 14% of the study area are modelled as *stable*, depending on the consideration of *no data* areas. It could be argued that these results represent an over-prediction of landslide susceptibility; however, the region is clearly an area of extreme landslide hazards, a fact that is also underlined by recent landslide events. A large proportion of landslide-affected pixels (46.3% - 67.5%) are located in areas that have been modelled as potentially unstable. The highest concentration of landslides was found in areas of relatively high stability, i.e. *moderately-stable* and *quasi-stable*, indicating a poorer stability classification. It should be noted, that the study in Youfang catchment was hampered by the lack of detailed topographic data. Digitising the only publicly available topographic map, and the subsequent transfer to a 30 m grid resulted in a low accuracy DTM which strongly affected the SINMAP simulations. It can be expected that the simulation results would greatly improve if better topographic data became available, preferably from LiDAR. Additional improvements of the model results could be achieved by extensive field and laboratory measurements of the constituents of the *T/R* factor, which in this study had to be based primarily on the subjective interpretation of limited geotechnical data.

In contrast to the majority of SINMAP applications, this study used the entire landslide-affected area for the quality assessment of SINMAP results instead of the point of landslide initiation. Consequently, there is a tendency of higher fractions of landslides being located in low susceptibility areas because the run-out zones may also affect flat areas, which are not likely to experience instability.

Inevitably, uncertainties remain in the application of a regional landslide simulation model. In this study, uncertainties arise from the methodology applied and the input data used. SINMAP is based on the infinite slope stability model which simplifies the real conditions of slope stability. Still, many case studies showed that that appropriate assessments of slope stability can be made in spite of the inherent simplifications. Topographic data represent the most important input for the SINMAP model and some shortcomings for the Youfang catchment data set have already been discussed. In addition, data on the spatial distribution of landslides were used to validate the results of SINMAP. For the Swabian Alb, it was possible to only include shallow slope failures which relied primarily based on DTM-based mapping. In contrast, because of the large extent of the Youfang catchment, as well as the remote location and the absence of high-detail DTM data, it was not possible to carry out mapping campaigns similar to the Swabian Alb study site. Moreover, the 30 m pixel size made it impossible to detect or even represent small landslides from the topographic data. Moreover, due to the large size of many of the known slope failures in this region, it must be assumed that these are in many cases deep-seated and by definition not suited for SINMAP simulation. Another issue is the unknown age of the landslides, in particular in the Chinese study area where slope failures are larger and potentially very old. Arguably, one of the most important limitations of this study is the determination of geotechnical parameters which was significantly influenced by expert knowledge and subjective interpretation. To a certain extent, the uncertainties due to geotechnical parameter selection are accounted for by the integration of parameter ranges integrated into the SINMAP code and repeated modelling with SINMAP in order to calibrate the input parameters. Still, the *T/R* factor could not easily be determined because it is only used by SINMAP, and the information required deriving from it, for example, soil depth and information and landslide-triggering rainfall conditions, is not readily available and could only be assumed with great uncertainties. Using the assumed parameter values based on the SINMAP standard settings resulted in appropriate results, however, the sensitivity analysis revealed that under the used parameter range, *T/R* only has a very small influence on susceptibility modelling. From these results of this study, it cannot be concluded if the low influence of *T/R* is related to parameterisation, or to a general aspect of the SINMAP model.

Given these limitations, the presented work should be regarded as a basic estimation of the landslide susceptibility in the study areas. The resulting maps can be used to communicate the prevailing landslide susceptibility conditions and to highlight hot-spots of landslide susceptibility; however, such regional studies cannot replace more detailed site investigations.

6. CONCLUSIONS

This study presents the application of SINMAP to study areas with very different environmental and geomorphological conditions, data availability and sizes of study areas. A subsequent analysis of model sensitivity to geotechnical input parameters demonstrated a strongly varying influence of the involved parameters.

SINMAP allowed for a relatively quick computation of landslide susceptibility for large areas and generally assigned higher susceptibility classes to steep slope sections, and to areas where water flow convergence occurs. The results of this research show that a large proportion of the landslide-affected areas are located in areas for which high susceptibility was modelled. However, due to the limited availability of data, in particular the lack of high-detail topography data and verified geotechnical parameters of the critical soil layers involved in landsliding, this study can only represent a preliminary assessment of the regional landslide susceptibility. The simulation of landslide susceptibility with 10 m and 30 m input data in the Swabian Alb showed that both produced similar results despite the fact that small topographic features are not included in the coarser dataset. The most apparent differences could be observed in the transition zones between high and low susceptibility zones which are not well represented in the 30 m susceptibility map. The results suggest that 30 m input data can be used to derive appropriate susceptibility classifications when the size of the landslides is relatively large. Small landslides, close to the raster resolution and influenced by small scale topographical features, however, cannot be represented with this coarse base data. In contrast, the results of Youfang catchment had a lower quality with respect to the percentage of landslides being covered by highly susceptible areas, as well as the percentage of landslides within the high susceptibility classes. These poorer results for the Chinese study site can be attributed to the lack of more detailed topographic data, and highlight the benefits of LiDAR-based DTM for regional landslide analyses.

A sensitivity analysis of the geotechnical parameters was carried out to assess the influence of each parameter on the relative proportion of susceptibility classes. The results can be used by other researchers to calibrate the geotechnical parameters to achieve modelling results that better fit the distribution of slope failures in the respective study areas. According to the results, internal friction has the highest impact on the susceptibility simulation, while the *T/R* parameter only influences the model output to a small degree; however, this could also be related to the chosen parameter range and further tests including field measurements should be carried out.

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THE LAKES OF THE ROMANIAN BLACK SEA COAST. MAN-INDUCED CHANGES, WATER REGIME, PRESENT STATE

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Key-words: Black Sea coast lakes, man-induced, water regime, present state.

Abstract. Unlike other regions in Romania, lakes in Dobrogea are marginally positioned – closely connected to the presence of the Danube and the Black Sea. This characteristic/position is the result of paleogeographical evolution in the Quaternary and the current climatic conditions in Dobrogea. The paleogeographical evolution in the Quaternary resulted in the formation of several depressions at the edges of dry land, where fresh and salt/sea water accumulated. The lakes on the Romanian coast line are grouped into two types of genetic depressions, a fact partially reflected in their hydrological and physical-chemical properties – *fluvial-marine limans and marine lagoons*. Regarding *limans*, we would mention the largest one – *Babadag*, grafted into the valley of the two Northern Dobrogea rivers, Taiţa and Teliţa, situated on the western side of the *Razim-Sinoie lagoon* (the largest lacustrine complex in Romania); *Taşaul*, initially located at the mouth of the Casimcea River, flows into the Black Sea; *Techirghiol*, after the conflence of the two tributaries, Urlichioi (Derea) and Biruinţa; *Tatlageac*, at the end of the Dulceşti (Tatlageac) Valley, and *Mangalia*, in the Albeşti Valley. The most notable lagoon, by surface-area, is the *Razim-Sinoie lake complex*; *the Siutghiol Lake*, the old *Comorova Marsh* which drained, resulted in three recreational lakes – *Neptun, Cozia,* and *Jupiter*, as well as the *Herghelia-Mangalia Marsh.* In terms of drainage-basin size, underground water-sources, links to coastal marine waters, and the semiarid, temperate-continental climate of Dobrogea, the spectrum of the chemical composition-mineralisation gradient of lake water, in natural conditions, varied and still varies from *fresh, brackish, salty and hypersalty water*. Man-induced changes of the lacustrine area, of drainage basins and of the links to coastal marine waters have resulted in significant structural modifications of the lacustrine ecosystems, in terms of use.

1. GENERAL CONSIDERATIONS

Background of research. During the first half of the 20th century, significant researches were conducted on a number of littoral lakes: Mangalia (Brătescu, 1915), Techirghiol (Pascu, 1900; Bujor, 1900; Mihăilescu, 1928; Mrazec, Sturza, 1932; Ţuculescu, 1965), Siutghiol (Lepşi, 1933), Taşaul (Brătescu, 1922), and Razim (Brăileanu, 1938; Zemiankovski, 1951; Murgoci, 1912).

During the second half of the 20th century, numerous research-works on the littoral lakes focused on different issues, such as: *the relations between the sea level variations and the genesis of the lacustrine depressions* (Blehu, 1962; Banu, 1964; Coteţ, 1970; Panin, 1983; Vespremeanu *et al.*, 2004); *the present morphobathymetric configuration* which has triggered changes in the hydrological, hydrochemical and hydrobiological regime, and consequently in the lacustrine ecosystems, with impact on their use (Gâştescu, 1971, 1998; Gâştescu, Breier, 1976, 1982; Gâştescu, Nicolae, 1981; Witzel *et al.*, 1964; Bondar, 1970; Nicolae, 1969; Breier, 1976; Romanescu 2006; Breţcan, 2007; etc.).

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Geographical position of the lakes. The marginal position of lakes in Dobrogea, related to the Danube and to the Black Sea (Pontus Euxinus), is the result of paleogeographical evolution during the Quaternary, while their hydrological features have been shaped by the present climatic conditions. On the sea coast eastern side, one can find several important lakes having various hydrochemical features and uses (Fig.1).

The Western-Dobrogea coast of the Black Sea is an area inhabited since the Antiquity, a fact proven by the *ruins of fortified cities* (Calatis-Mangalia, Tomis-Constanţa, Histria-Sinoie, Argamum-Doloşman, and Heracleea-Razim) (Fig. 1).

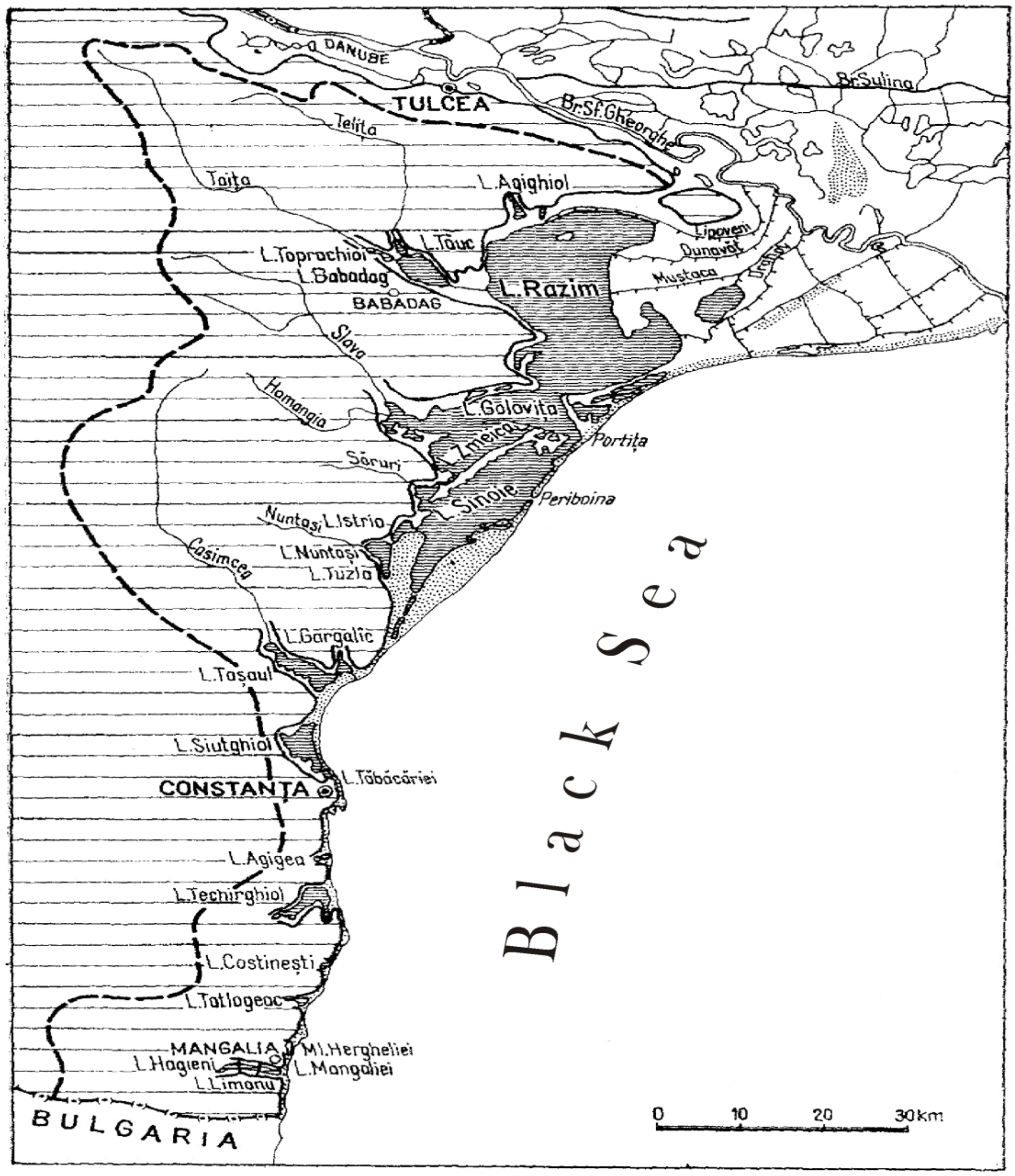

Fig. 1 – Lakes on the Romanian Black Sea coast.

Paleogeographical evolution. During the Quaternary, when liman and lagoon depressions were being formed, the Romanian sea coast and the Black Sea itself aroused the interest of several Romanian and foreign researchers.

By correlating and synthetizing research conclusions, one can see that the Romanian sea coast (which includes *the Danubian liman*, currently the Danube Delta and the *Halmyris Gulf*, occupied by the Razim-Sinoie lacustrine complex), was affected by *three main Black Sea stages* in the Holocene-Quaternary: first stage – *the Flandrian transgression* – Feodorov, 1961); the *Neolithic transgression* (Banu, 1964); and the *Dobrogean transgression* (Coteţ, 1970), the sea level at that time being 3-to-5 m above the present zero-meter one; the second stage – the *Fanagorian, Dacian and Histrian transgressian*, sea level 1-to-5 m below the present one (from the: 7th–6th cc BC to 5th–6th cc/AD); the third stage – *Nimphean, Walachian, Razim transgression*, sea level returned to the current one and the shore separate the present limans and lagoons emerged (the second and third stages are named as such by the above authors – Feodorov, Banu, and Coteţ) (Fig. 2).

Morphological types of lacustrine depressions. In terms of genesis, the lakes of the Romanian sea coast belong *to two categories of depressions*, partially reflected also in their hydro-and-physical-chemical features: *fluvial-marine limans* and *marine lagoons*. Among the *fluvial-marine limans*, the largest one is *Babadag*, situated in the north of Dobrogea, at the western margin of the Razim-Sinoie Lagoon; *Taşaul* at the mouth of the Casimcea River, which once used to flow into the Black Sea; *Techirghiol* after its two tributaries – Urlichioi (Derea) and Biruinţa confluenced; *Tatlageac* at the end point of the Dulceşti Valley (Tatlageac); *Mangalia* along the Albeşti Valley. Quite an impressive *lagoon area*, is the *Razim-Sinoie lacustrine complex*, occupies the ancient Halmirys Gulf; *Siutghiol Lake*, a *marine lagoon*; worth mentioning, are also the ancient *Comorova Marsh* (which, drying up, led to the formation of three leisure lakes – Neptun, Cozia, and Jupiter) and the *Herghelia-Mangalia Marsh* (Table 1).

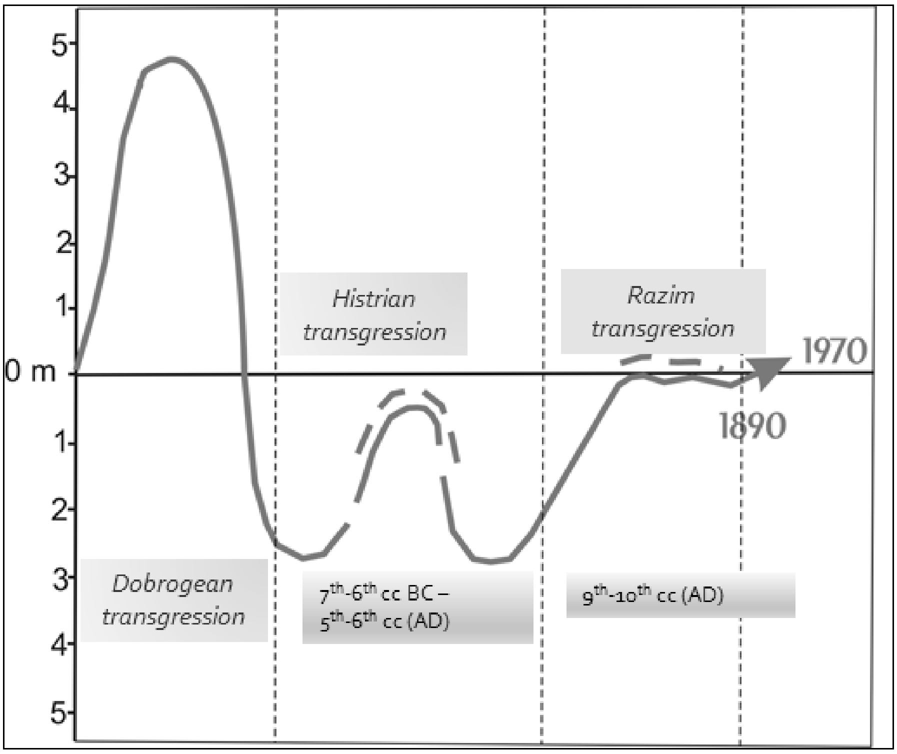

Fig. 2 – The Romanian Black Sea evolution during the Holocene-Quaternary (Coteţ, 1970).

Table 1

The morphohydrographical features of the littoral lakes (Gâştescu, Breier, 1976)

Lake	Genetic types	Altitude (m)	Surface-area (km^2)	Volume (mil.m^3)	Maximum depth (m)	Average depth (m)
Razim -Sinoie	lacustrine complex	0.50	867.7	1440.71	3.5	1.67
Taşaul	liman	1.24	23.35	57.0	3.75	2.40
Gargalâc	liman	0.9	5.20	7.2	1.9	1.40
Siutghiol	lagoon	2.16	19.60	88.7	17.05	4.65
Tăbăcăriei	liman	1.25	0.99	2.1	6.15	2.15
Agigea	liman	0.83	0.60/0.35	0.26	0.7	0.40
Techirghiol	liman	-1.5/1.5	11.61	41.8	9.75	3.60
Costineşti	liman	0.25	0.07	0.02	0.35	0.25
Tatlageac	liman	0.94	1.40	21.5	2.5	1.58
Mangalia	liman	0	3.10	15.7	13.0	6.0
Limanu	pond	4.4	0.52	0.6	2.5	1.1

Present climatic and water features. Low precipitation *(X)* (under 400 mm/year), high evaporation *(Z)* (850-900 mm/year), the accumulation of precipitation waters in the liman *and lagoon* depressions is insufficient to ensure a constant water balance *(X=Z)* and, the formation/persistance of lakes. However, under natural conditions, the presence of the Romanian coastal lakes is due to underground discharge *(U1)*, connections with the marine coastal waters *(Y2)* and the contributions of individual drainage basins *(Y1)*. Therefore, the result is a water balance deficit or surplus, according to the balance equation $(X + Y1 + U1) - (Z + Y2) = \pm \Delta V$.

Under the present local and regional geographical conditions, the water balance structure has changed due to anthropic activities and economic interests.

Chemical charactersistics. The chemical make-up ranges from *fresh water* (Siutghiol), *brackish water* (Sinoie)**,** and *salty water* (Nuntaşi) to *hypersalty water* (Techirghiol), in correlation with drainage-basin size, underground water sources, and connections with the marine coastal waters, against the background of the semiarid temperate-continental climate of Dobrogea.

2. MAN-INDUCED CHANGES IN THE MORPHOHYDROGRAPHICAL FEATURES OF LAKES

The anthropic interventions on the lake pattern, the drainage basins and the connections with the marine coastal waters have significantly changed the *structure and use of the lacustrine ecosystems* (Mangalia, Tatlageac, Techirghiol, Agigea, Siutghiol, Taşaul, and Razim).

Mangalia Lake occupied a 40 m-wide sinewy valley, modified by abrasion, If had a low chemical concentration (3.96‰ in 1906, 1.6‰ in 1933), being influenced by drainage-basin waters (784 km^2) and underground waters. Since 1953, the cutting of the offshore bar led to the formation of three lakes – *Mangalia*, turned into a marine gulf, while *Limanu* and *Hagieni* became fishery ponds; also the hydrological regime and the chemical concentration were essentially modified. Thus, in *Mangalia Lake*, which is connected to the sea waters, mineralization (15–16‰) and the hydrochemical type (chloro-sodic magnesium) are similar; on the other hand, *Limanu* and *Hagieni* lakes have low mineralizations (0.7–1.0‰), being of a bicarbonatted-sodic hydrochemical type, therefore with a tendency to fresh continental waters.

Tatlageac Lake occupies the lower, sinewy and enlarged sector of the Dulceşti Valley, drainage basin 144 km^2, being separated from the sea waters by an offshore bar, 60–80 m wide and 2 m high, crossed by the Constanţa-Mangalia railway. Under natural conditions, the lake used to have an opening to the sea, but at present, the lake being used as fishery pond, the opening is under control.

Costineşti Lake, small-sized (0.07 km^2, drainage basin 21 km^2), with insignificant morphobathymetric features; the offshore bar (ca 500 m long and 100-150 m wide), which separates it from the sea, is an important beach used by the spa-and-health resort of Costineşti.

Agigea Lake, small-sized, situated south of Constanţa, along the homonymous valley (drainage basin 40 km^2) was separated from the sea by an offshore bar crossed by the Constanţa-Mangalia railway. The construction of the Danube-Black Sea Canal made the last branch to Constanţa-Agigea port go through Agigea Lake, thus reducing its surface-area to 0.35 km^2, affecting an important avifauna reserve and turning the lake into a fishery.

Taşaul Lake, linked to the sea, had formerly two estuaries: the first and the largest occupies a part of the lower Casimcea River sector (69 km long, drainage basin 740 km^2), the second, *Gargalâc Lake*, is situated along the Corbu Valley (7 km long; drainage basin 39 km^2). Both of these lacustrine depressions where much enlarged, first by marine abrasion and later by lacustrine abrasion; the opening to the marine water-bearing structure was dammed by an offshore bar, between Năvodari and Capul Midia.

Nearby these lakes, especially on the offshore bar, important changes have been triggered by the Poarta Albă/Basarabi-Capul Midia branch of the Danube-Black Sea Canal and the PETROMIDIA Refinery with its port. The Canal goes alongside the whole border of *Lake Taşaul*, is an offshore bar that ends up in areas where fluvial barges are moored. At the same time, the lakes are currently used as fisheries, and their opening to the sea is controlled in terms of level variation.

3. HYDROLOGICAL FEATURES

The hydrological features of the lakes have been highlighted and interpreted based on the data recorded by the network that monitors the hydrological parameters and the management of the littoral lakes (levels, precipitation, air and water temperature, evaporation, chemistry, waves) (Fig. 3, Table 2).

Table 2

The main hydrometric stations monitoring coastal lakes

Lake	Hydrometrical station	Surface-area (km^2)	Altitude of lake (RMNm)	Established in
Razim	Sarichioi	415.0	0.50	1956
Goloviţa	Jurilovca	118.7	0.50	1956
Istria	Nuntaşi	5.60	0.80	1979
Nuntaşi-Tuzla	Nuntaşi	10.50	0.78	1979
Taşaul	Luminiţa I	23,35	1.24	1956
Gargalâc/Corbu	Luminiţa II	5.20	0.90	1956
Siutghiol	Mamaia-Băi	19.60	2.16	1956
Tăbăcărie	Constanţa	0,99	1.25	1956
Techirghiol	Techirghiol	11.61	-1.5/1.5	1958

Water-level variation is an important parameter that reflects volume variation, however, it is seasonal and multiannual level variation, that reveals *the general tendency* of climatic factors.

Level variation also depends on the configuration of the lacustrine depression, the wind fetch, seiches on the larger aquatic surface (eg. Razim, Siutghiol lakes), or drainage-basin size, entailing high floods, etc. (Mangalia, Tatlageac, and Techirghiol lakes).

The analysis of water levels covered two different periods: 1967–2005 (Taşaul-Gargalâc, Siutghiol-Tăbăcărie, and Techirghiol); 1979-2005 (Istria, and Nuntaşi). One can note that the average levels in the analysed period are situated 260 cm above the “0” level (Fig. 3).

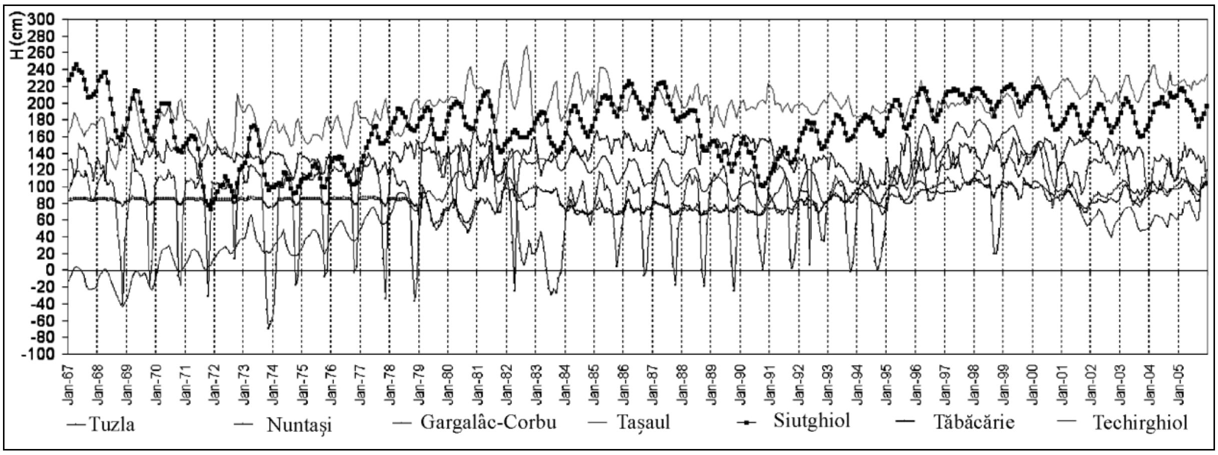

Fig. 3 – Water-level variation.

The multiannual lake-level variation showed a slightly increasing tendency, except for Techirghiol Lake, which kept decreasing after the year 2000.

In the case of the three lakes studied, the most significant level variations were due to direct (Siutghiol and Razim) and *indirect* (Techighiol) anthropic interventions.

4. CASE-STUDIES

Given the man-induced lakes changes, as well as the existing hydrometric data and their importance, our *case-studies* focused on the hydrological parameters of *Techirghiol* and *Siutghiol lakes* and the *Razim-Sinoie lacustrine complex.*

4.1. The Techirghiol Lake

Lake Techirghiol (11.6 km^2, max. depth 9.75 m, area drainage basin 165 km^2 and underground drainage basin 350 km^2) is the most important fluvio-marine liman, separated from the sea by a 200 m-wide and 2,000 m-wide alluvial bank,used as a beach, between Eforie Nord and Eforie Sud. It has come to occupy a much larger depression, initially through karst and marine abrasion processes, and later on lacustrine abrasion processes.

The Techirghiol Lake is a model of semiarid climatic conditions (high evaporation compared to reduced precipitation, isolated drainage basin without any outlet) and of *level variation, hydrological balance and salinity.*

Its level varied from -1.50 m to “0” m in 1909 and to +1.70 m in 1997–1998, followed by a decreasing tendency down to 0.60 m in 2010.

The dramatic level increase of the Techirghsiol Lake was triggered solely by the irrigation systems, which began functioning in the early 1960,s , their influence on the water balance through input on ground and underground basins was started being felt in the 1970s (Fig. 4).

Analyzing the basic water-balance components over 1967–2005 its structure under natural conditions was:

$$(X + Y1 + U1) – (Z + Ii) = \pm \Delta V,$$

where: *X*, rainfall on the lake; *Y1***,** surface runoff influenced by the irrigation system; *U1*, underground discharge; *Z*, evaporation; *Ii*, infiltration from the lake via the offshore bar; $\pm\Delta V$, volume difference.

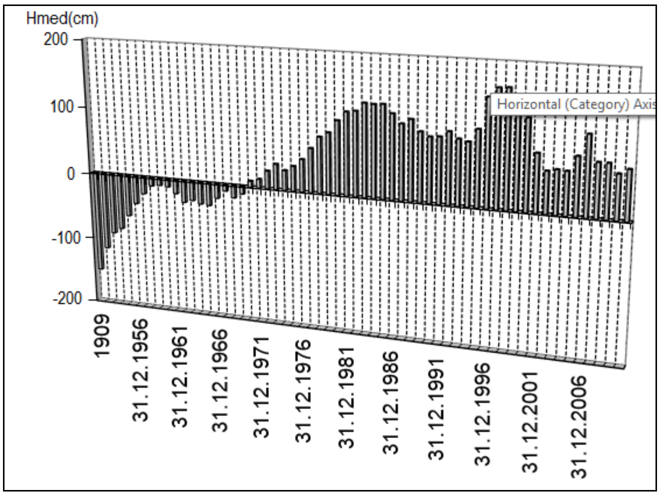

Fig. 4 – The Techirghiol Lake water level variation (1909-2010).

Insofar as the analysed period is concerned, one can notice some extreme values: *precipitation* (*X*) between *225 mm – 1976* and *889 mm – 2005*; *evaporation (Z)* between *587 mm – 1985* and *972 mm – 1971*; therefore *X < Z.*

Yet, during this period, the values recorded in 2005 were *X = 889 mm* and *Z=734 mm*, therefore *X>Z***,** which means an exceptional situation in the specific conditions of Dobrogea.

The influence of the irrigation systems significantly modified the water balance structure:

$$(X+ Y1+U1) – (Z+Ip+Ii) = \pm \Delta V.$$

To diminish the fresh water level in the lake, both via (*Y1)* and (*U1*), the procedure used was the evacuation of significant water volumes by pumping them to the sea and to Constanţa City (*Ip*) (Fig. 5).

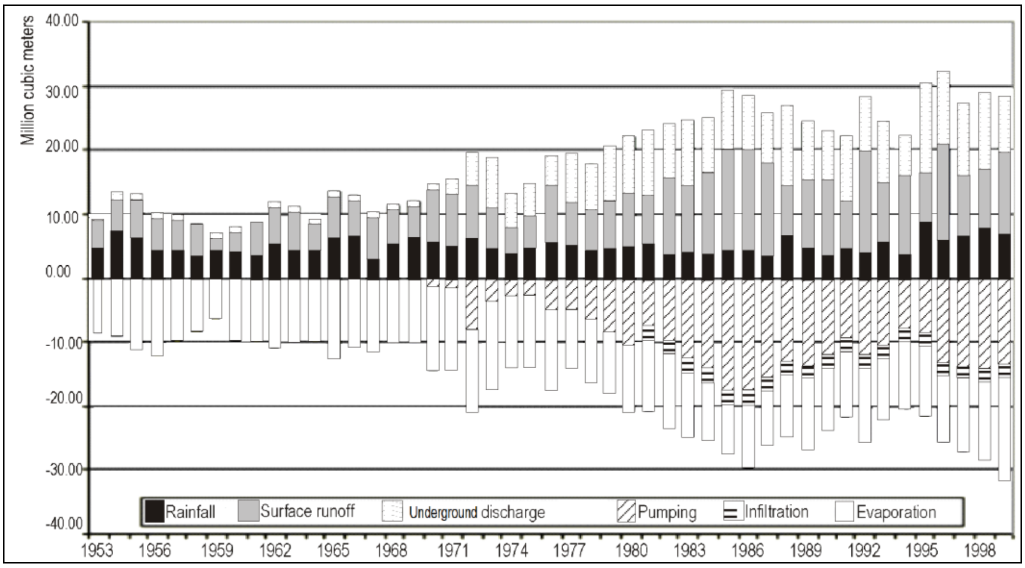

Fig. 5 – The Techirghiol Lake water balance over 1953-1999.

As a consequence, the water volume increased from 57.5 mill. m^3 in 1967 to 80.5 mill.m^3 in 1998, determining a *salinity decrease* from 81.5 ‰ in 1969 to 55.0 ‰ in 2000 that affected the normal genesis conditions of therapeutic mud (peloid), of and the balneo-therapeutic quality of the water (Trică, 1977) (Figs 6, 7).

The relation between lake-level increase and salinity decrease is: $Y = 0.4652 + 108.81$ and $R^2 = 0.5818$.

Beside lower salinity values, the Techirghiol Lake level increase, led to: the flooding of Eforie Sud and Techirghiol spa resorts located on the side of the lake; landslides and bank erosion, especially on the left /southern bank; deterioration of the hygrophile vegetation on the left/northern bank caused by higher water levels.

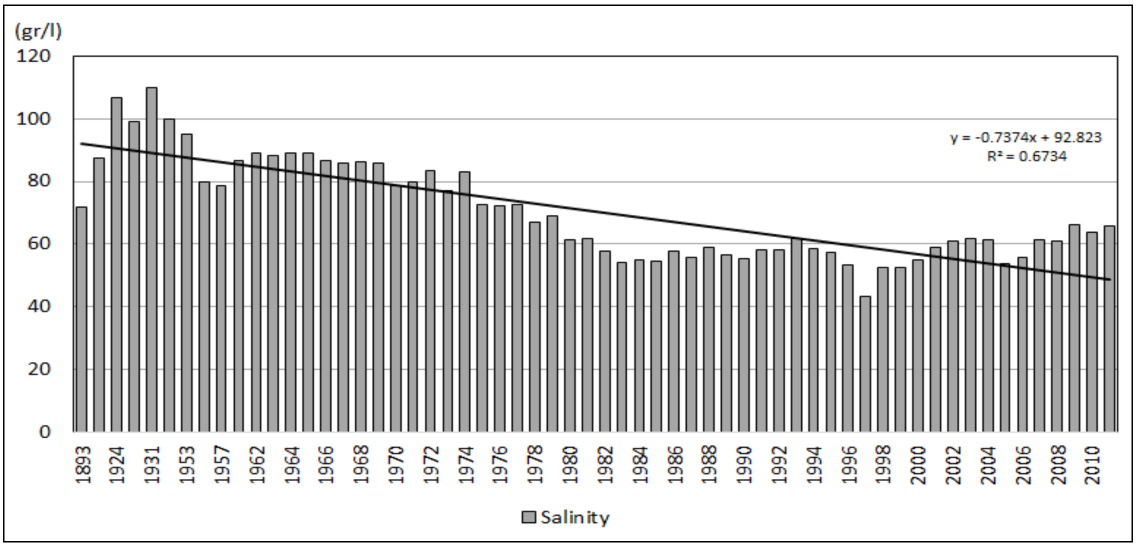

Fig. 6 – Salinity in the Techirghiol Lake (1893–2010).

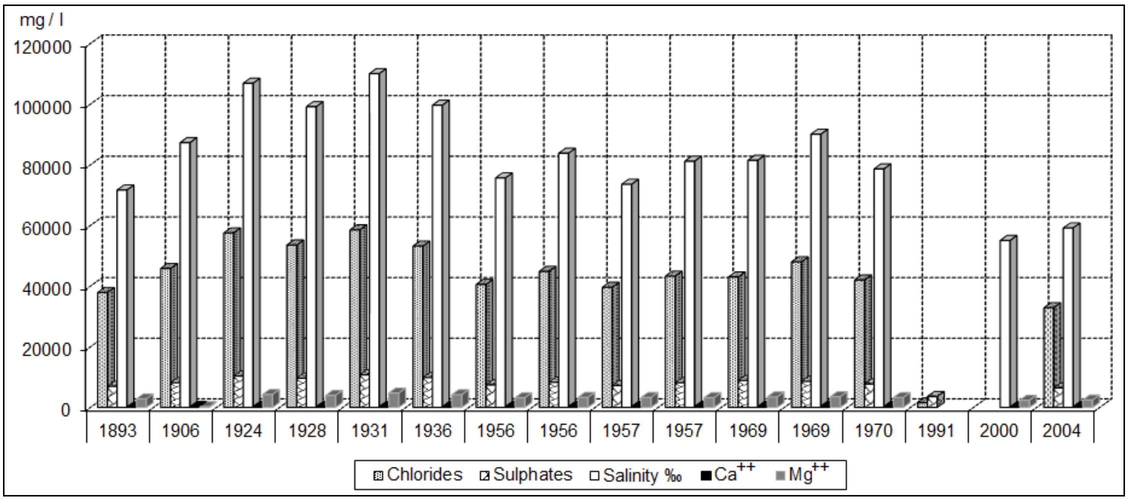

Fig. 7 – The Techirghiol Lake – hydrochemical structure.

The measures taken to diminish the excessive fresh-water intake in the lake by surface runoff *(Y1)* and underground discharge *(U1)*: drillinigs in the drainage basin to pump out the underground water surplus, drains to collect the fresh water in the Urlichioi and Biruinţa Valleys, draining the water towards the Tatlageac Valley; drills around the lake for catching, collecting and pumping the underground intake; building two dams to hold the fresh waters – one at the tail of the lake on the Biruinţa Tributary and another on the Tuzla Gulf; a drainage canal from the lake to the sea via the offshore bar, as a preventive measure in case the water level might rise and affect the facilities between Eforie Nord and Eforie Sud (Fig. 8).

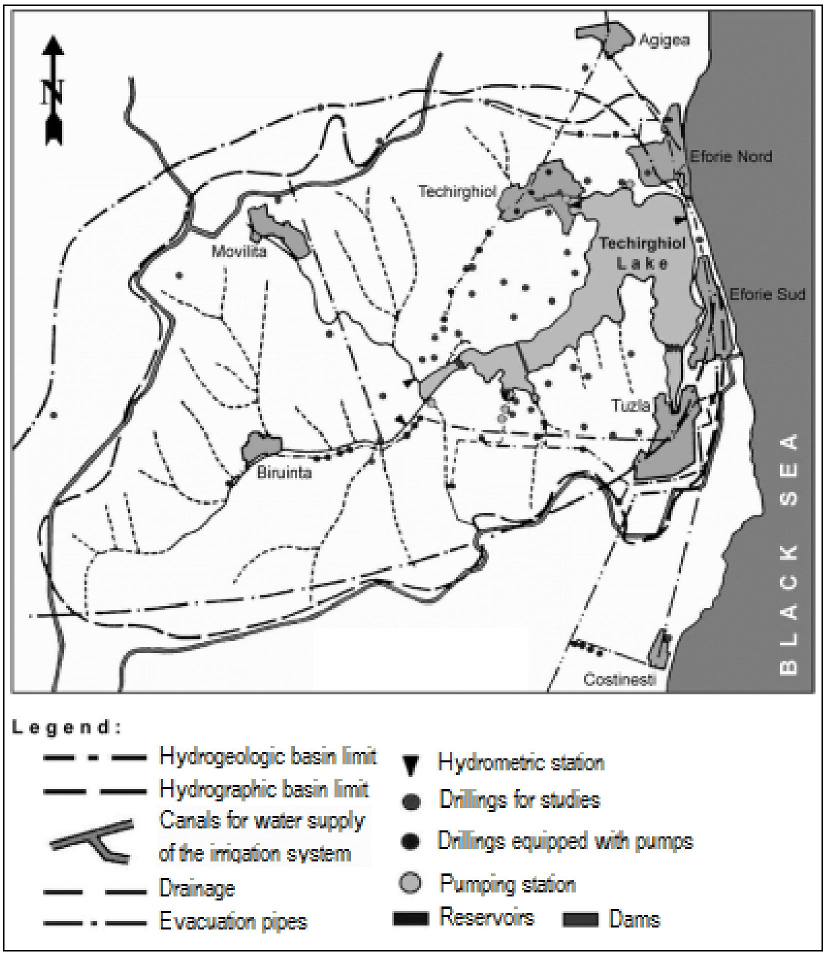

Fig. 8 – Hydrographic basin of the Techirghiol Lake.

4.2. The Siutghiol Lake

The Siutghiol Lake depression, a marine mini-lagoon, emerged in the wake of the Capidava-Ovidiu fault, which separates the Jurassic limes from the Cretaceous limes, affected by karst processes and favouring a significant underground water supply from submerged springs, determining the water-balance structure, the waters being usually in excess and fresh.

The lake is separated from the Black Sea by an offshore bar made up of fine sands, 300 to 600 m wide and about 15 km long, between Constanţa City and Mamaia (village), where Mamaia spa-and-health resort has developed (Gâştescu, 1971).

The Siutghiol Lake, which covers 19.6 km^2, maximum depth 17.15 m, is situated in one of the karst dolines present on the almost plain bottom at an average depth of 4.6 m. In the lake area stands Ovidiu Island – close to the homonymous town. This abrasion witness, made up of Jurassic limestone, covers a 2.6 ha area of reaches (max. 5 m high). It represents a complementary tourist objective for those who visit Mamaia resort (Fig. 9).

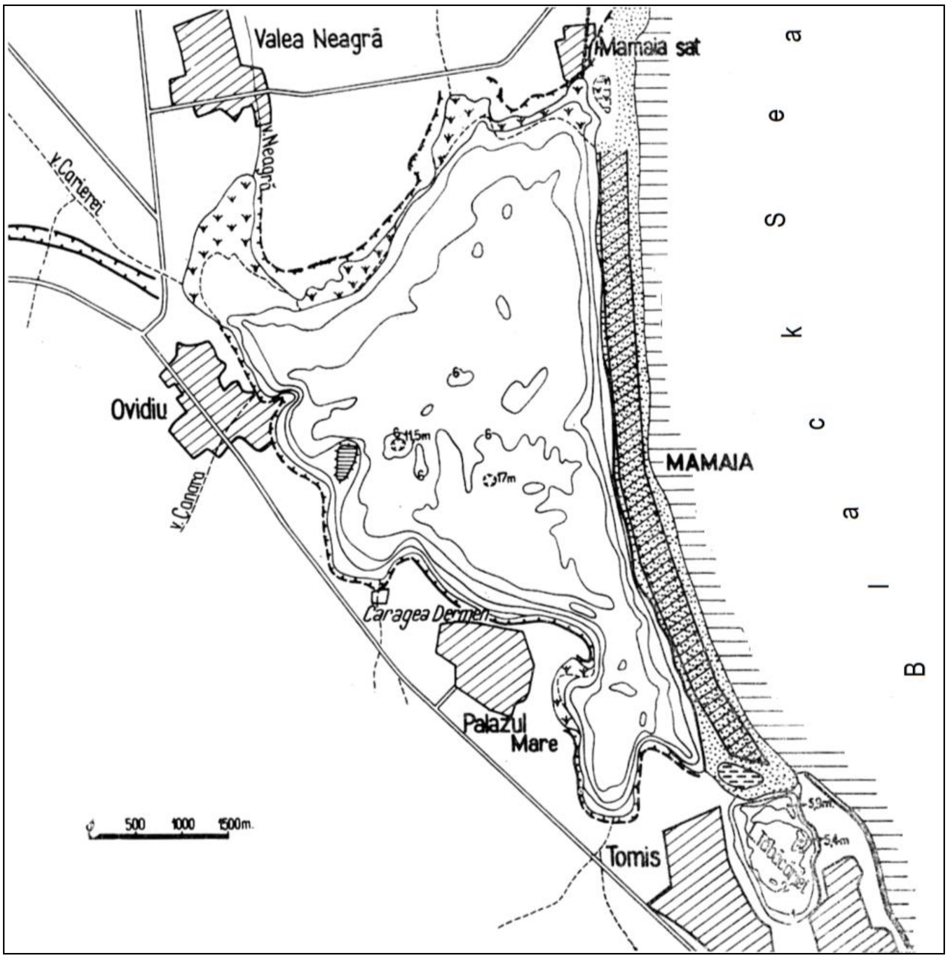

Fig. 9 – The Siutghiol Lake-bathymetric map (Gâştescu, 1971).

Due to the underground discharge via numerous submerged springs, the water balance is above zero and the multiannual average level around 2 m, determines the drainage towards the Black Sea via the Tăbăcărie Lake (Fig. 10).

In natural regime, the water balance has the following structure:

$$(Y1 + X + U1) - (Z + Y2 + Ii) = \pm \Delta V$$

where: ***Y2,*** discharge into the Black Sea; *Ii* seaward infiltration through the offshore bar.

In the 1967–2005 period, these two fundamental components registered the following values: *X* = 386 mm and *Z* = 844 mm with significant variations (*X* between 214 mm in 1983 and 692 mm in 2004; *Z* between 625 mm in 1985 and 1,015 mm in 1970).

The compensation of the water deficit, resulting from the values of components (*X)* and (*Z),* in the case of a small drainage basin (92 km^2), is due to the underground discharge ***(U1)*** and also discharge into the Black Sea *(Y2).*

Before anthropic interventions, underground supply *(U)* reached 89% of the values of water balance components (47.6 mill. m^3 in the hydrological year 1958–1959).

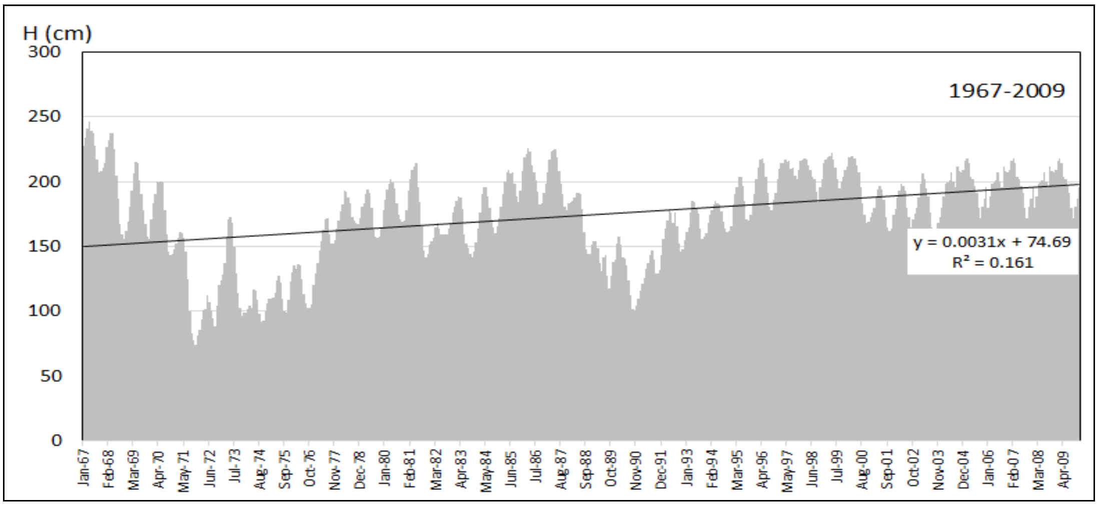

Fig. 10 – Water-level variation –Siutghiol Lake (1967–2009).

After 1970, the water supply of Constanţa City from underground sources (Caragea Dermen and Cişmea) reduced the volume of the underground component (*U1*) part of the water balance. Besides, water used to be taken directly from the lake for irrigation and for some industrial companies.

In this situation, the water balace structure equation was:

$$(X + Y1 + U1) - (Z + Y2 + Ii + C) = \pm \Delta V$$

where: *C* represents the water consumption / extractions from the lake.

The anthropic interventions triggered up to 1 m lake-level decrease, even cutting off discharge into the Black Sea *(Y2)*. In order to avoid the seaward infiltration through the offshore bar (*Ii*), jeopardising the quality of fresh lake water, all water extractions were forbidden (Fig. 11).

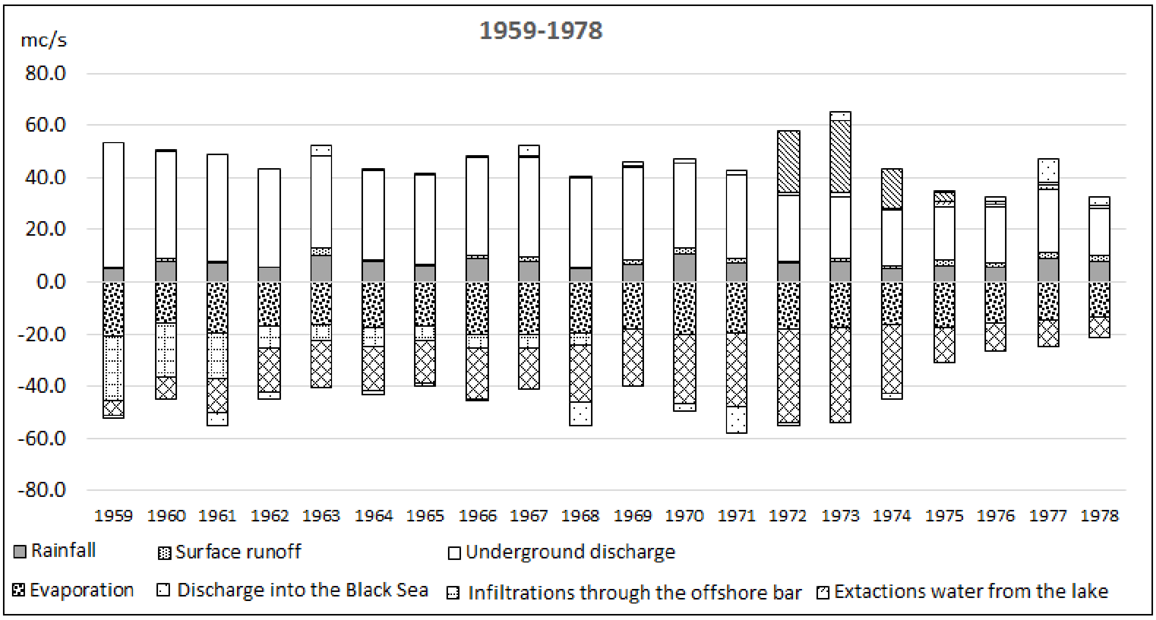

Fig. 11 – The Siutghiol Lake – water balance.

Due to the quantitative values of the water balance component, under both natural conditions and anthropic intervention, the Siutghiol Lake water was and remained fresh water, with under 1‰, mineralization, except for the years 1961–1963 when this threshold was slightly exceded, being of the bicarbonated sodium-magnesium towards the chlorinated sodium-magnesium type (Fig. 12).

This hydrochemical structure reflects a twofold influence: on the one hand, the dominantly underground water imput and, on the other hand, the reversible relation with the Black Sea via the offshore bar.

Having in view the morphobathymetric and hydrological features, as well as its geographical location near Constanţa City and Mamaia spa-and-health resort, the Siutghiol Lake is used mainly for nautical competitions and leisure sports, sporting fishing and amateur fishing (Gâştescu, Nicolae, 1981, Gâştescu, Breţcan, 2003).

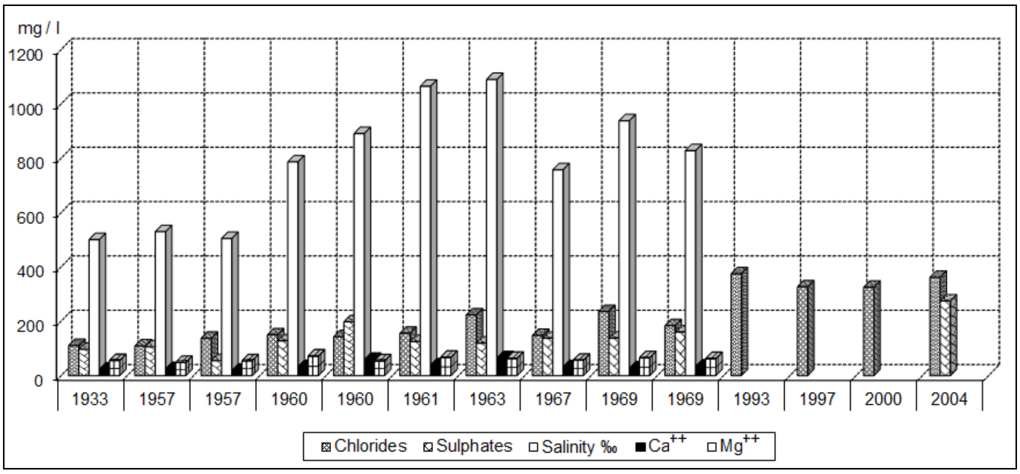

Fig. 12 – The Siutghiol Lake – hydrochemical structure.

4.3. The Razim-Sinoie lacustrine complex

The largest lacustrine complex on the Romanian sea coast and in this country (863.5 km^2), the Razim-Sinoie comlex includes several lakes: Razim (415 km^2), Sinoie (171.5 km^2), Goloviţa (118.7 km^2), Zmeica (54.6 km^2), Babadag (23.7 km^2), Nuntaşi-Tuzla (10.5 km^2), Istria (5.6 km^2) and a few more satellite lakes (Breier, 1976) (Fig. 13).

This complex occupies the former Halmyris Gulf, which started being gradually separated from the Black Sea about 2000 years ago. The hydronym Halmyris has been "borrowed" from the homonymous fortified city of the Antiquity, situated north of the Razim Lake area.

The lacustrine complex is separated from the Black Sea by a series of offshore bars, several of them fragile – Perişor, Periteasca, Periboina, while the largest one being Chituc; the western shore of the Razim Lake represents a *"fossil"* cliff of the former Halmyris Gulf.

The complex encompasses are three islands – Grădişte, Bisericuţa and Popina, the last one, which is also the largest, represents a 47 m-tall outlier of north-Dobrogea, whose steppe vegetation and fauna entitled it to being declared strictly protected area of the Danube Delta Biosphere Reserve.

The maximum depth of 3.5 m in the midst of the Razim Lake is the result of the clogging and closure of the Halmyris Gulf by the offshore bars, a situation that determined the abandonment of the *Greek city of Histria,* situated on a cape formed of green schists, on the border of Sinoie Lake, and which was inhabited between the 7th century B.C and the 5th century (AD) (Bleahu, 1962).

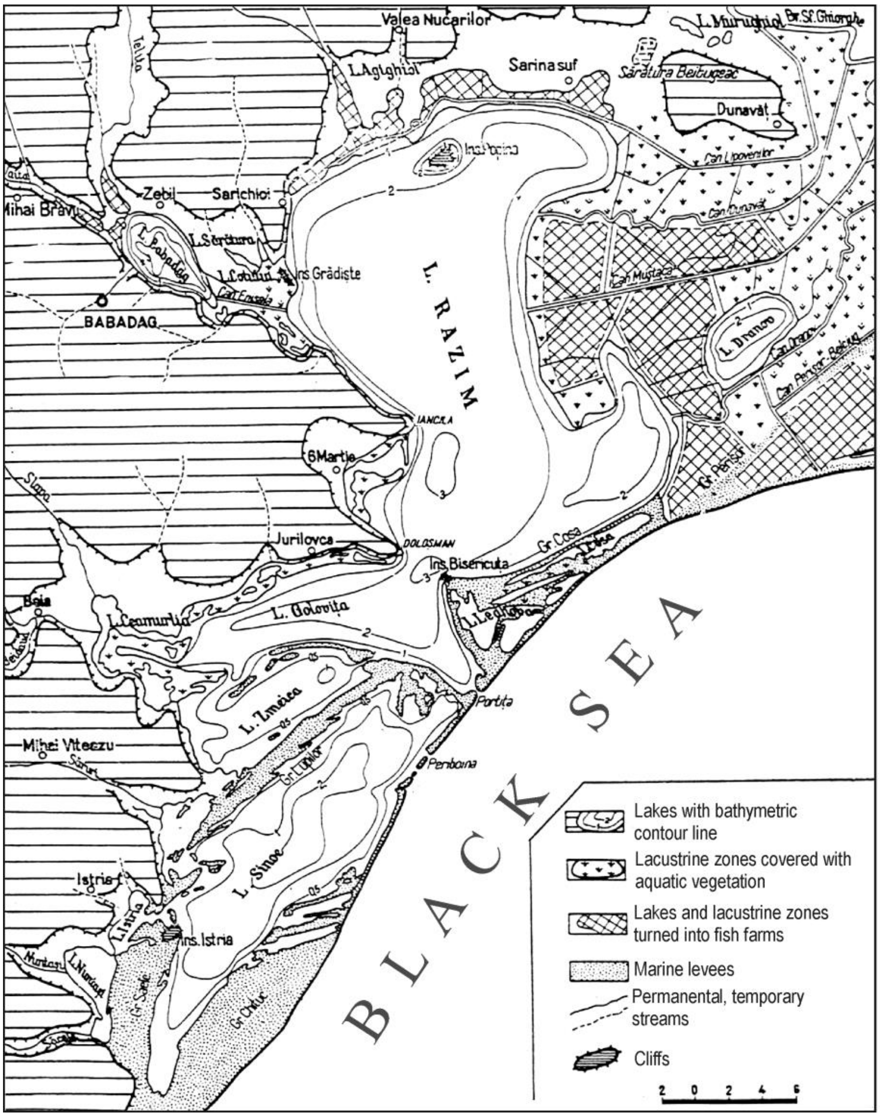

Fig. 13 – The Razim-Sinoie lacustrine complex.

To provide a solution to the water deficit, the Dunavăţ and Cerneţ backwaters were extended (in 1905, 1912 and 1933) by connecting the Dunavăţ and Dranov canals to the Sfântu Gheorghe Arm and the Razim Lake.

An important change in the Razim-Sinoie complex ecosystems took place 1970, when Gura Portiţei, the main connection with the sea, was dammed; the whole complex has only one connection through Periboina (Sinoie Lake).

When this lacustrine environment was in a natural state, that is, before human intervention, the lake complex was connected to the Black Sea through a breach in the marine levee, a kind of gateway (‘periboine’ and ‘portiţe’). A major link between the Black Sea and the Lake Razim was Gura Portiţei, which enabled very close permanent exchange between lake and sea levels.

The dam, built in 1970, destroyed the link, and Lake Razim remained a fresh water basin used for irrigation in the adjoining area. Irrigation water is supplied by the Danube through the Sfântu Gheorghe Arm.

These man-induced changes (water coming in from the Danube in the north- Lake Razim-and from the sea in the south-Lake Sinoie) have altered the mineralization, i.e. fresh water turning to brackish and saline in the more isolated lakes of the south (Nuntaşi-Tuzla).At the same time, the area was put to new uses, e.g. fish farming, irrigation, spa-and-tourism.

The *unmodified water balance model* over 1956-1970**:**

$X + Y1 + YD - Z - I2 = \pm \Delta V$, where: *X*, rainfall; *Y1*, surface runoff, *YD***,** runoff from the Danube via canals; *Z* evaporation, *Y2* discharge into the Black Sea and $\pm \Delta V$ lacustrine complex water volume stocked or evacuated within a certain time interval (Fig. 14).

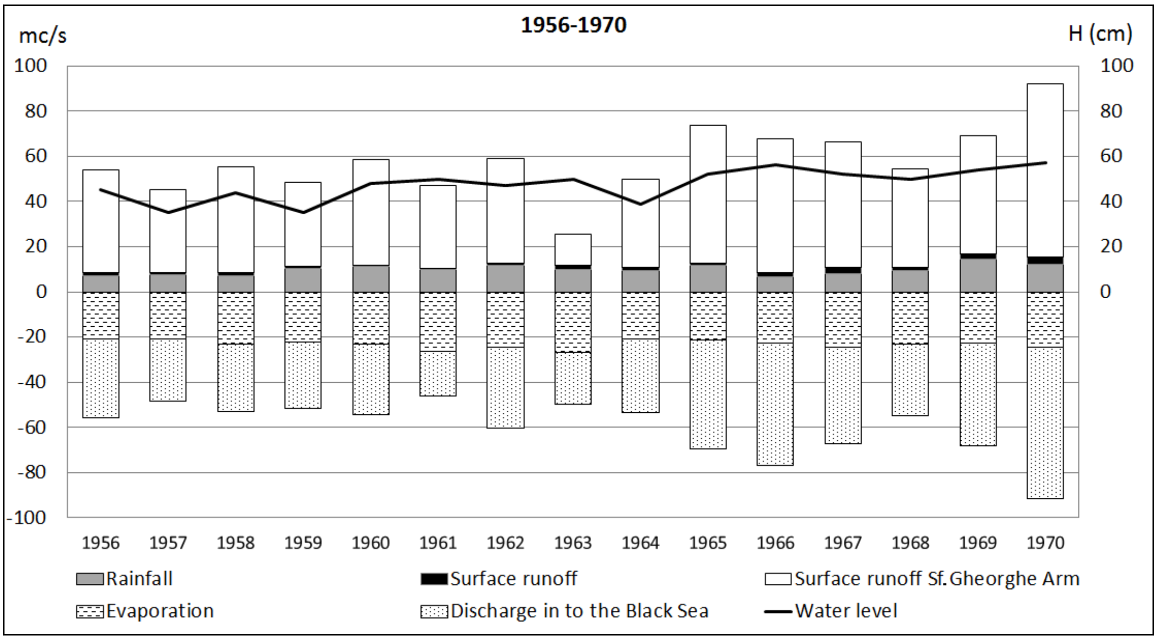

Fig. 14 – The unmodified water balance (1956–1970).

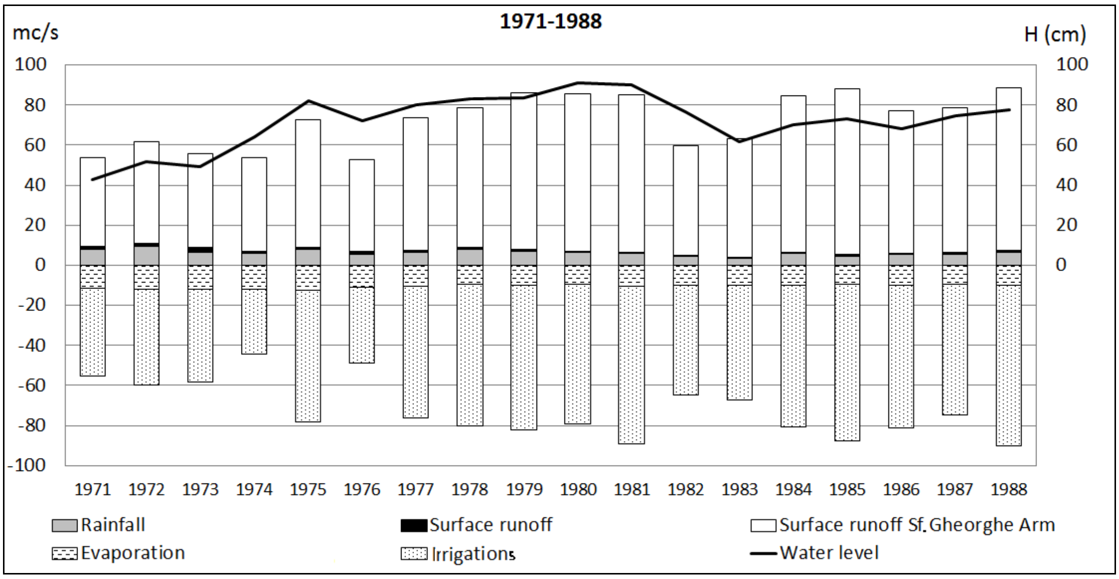

Fig. 15 – The modified water balance (1971–1988).

The *modified water balance model* over 1971–1988:

$$X + Y1 + YD - Z - IR - I2 = \pm \Delta V,$$

where: *IR* is the water volume for irrigation (Fig. 15).

The great diversity of the Razim-Sinoie lake complex ecosystem, as well as the vicinity of the Danube Delta, made the authorities declare the area a nature reserve in 1990- the *Danube Delta Biosphere Reserve***,** which encompasses both geographical units.

5. CONCLUSIONS

- The geographical position of Dobrogea's coastal lakes is the result of paleogeographical evolution during the Quaternary, their hydrological features having been shaped by the present climatic conditions.
- In the present semiarid conditions – low precipitation *(X)* (under 400 mm/year), and high evaporation *(Z)* (850–900 mm/year), the accumulation of meteoric waters in the lacustrine depression is insufficient to ensure a constant water balance *(X=Z).*
- The persistence of the Romanian coastal lakes is due especially to the underground discharge *(U1)*, their connections with the coastal waters *(Y2)* and the intake from individual drainage basins *(Y1).*
- In harmony with drainage basin size, underground water sources, and coastal waters connections against the background of the semiarid temperate-continenental climate of Dobrogea, the chemical composition of lake waters ranges from *fresh to brackish, salty* and even *hypersaline*.
- Human intervention on the lacustrine water-bearing structure, on drainage basins and on the connections with the coastal sea waters has determined significant changes in the *structure and uses of the lacustrine ecosystems*.
- Under the present local and regional geographical conditions, the water balance structure of lakes has been changed by anthropic activities, in terms of hydrochemical features and economic interests.
- Seeing the modifications occurred in the morphohydrographical configuration of the lacustrine depressions, influencing also the water regime, especially level the variation and the structure of the water balance components, the *case-studies* analyzed herein are Techirghiol, Siutghiol şi Razim-Sinoie lakes.
- *The Techirghiol Lake* (–1.50 m), isolated from the sea, hypersaline water (110‰), has special spa qualities; irrigation waters (after 1960) rose the lake level by +1.5 m, salinity decreasing to 55‰ (in 2000). In order to protect its spa qualities, a project limiting the intake of fresh ground and underground water was elaborated and implemented, the situation improving after the year 2000.
- The *Siutghiol Lake***,** with a special underground water intake, had and still has fresh water, yet it has experienced volume and level variations, because of the diminution of underground sources and the extraction of water for irrigation and other uses.
- The *Razim-Sinoie lacustrine complex*, being connected with the sea, is a *brackish water*, used only for fish breeding; once the connection with the Black Sea was cut, *fresh water* for irrigating the riverside area was taken from the Danube, thus changing the hydrochemical and faunistic composition of this lake complex.

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THE GREAT BUSTARD (*OTIS TARDA* L.) POPULATION DYNAMICS IN ROMANIA

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Abstract. The paper based on archive material and field investigations, is a synthesis of the Great Bustard (*Otis tarda* L.) population dynamics in Romania, with focus on 1950, the year since when systematic observations on the species do exists. Besides, the chronological numerical evolution, and the complex causes responsible for the decline of this steppe bird, currently close to extinction in Romania, are also discussed. Not only is the Great Bustard listed among relict species, but also among the critically endangered ones.

1. INTRODUCTION

The Great Bustard is the most outstanding representative of the Eurasian steppe fauna.

An ornament of the steppes, formerly considered a true cynegetic "jewel" of Romania, it would later become simply an ornamental steppe element and eventually nothing more than a steppe symbol.

The most important trait of the Great Bustard population is number, a fundamental biostatistical element studied by the author in time and space. The Great Bustard effective is expressed in number of individuals (assessed in May by visual specimens recording method), but no numerical evidence for older periods of time does exist.

2. POPULATION DYNAMICS

In the Middle Ages, this species was "quite frequently seen" (Munteanu, 1986, p. 2), a reality mentioned also in *The Hieroglyphic History* written in 1705 by Ruling Prince Dimitrie Cantemir of Moldavia, who describes the Great Bustard as "a very common species" in that Principality (Filipaşcu, 1969). In the first part of the 19^{th} century, the Bărăgan Plain was crossed only by "the mail coach, by merchants and by Great Bustard hunters" (Mihăilescu, 1921, p. 264). Between 1820 and 1830, Great Bustard specimens could be seen "in almost all of Moldavia's plains" noted in his *Memoirs* Nicolae Şuţu, Ruling Prince of Moldavia (Revista Carpaţii, No. 3/1947, p. 49).

In the late 19^{th} and early 20^{th} centuries, "numerous Great Bustard birds populated all the plains of the country" (Munteanu, 1979, p. 155). In his work, *The Vertebrate Fauna of Transylvania*, printed in 1856, E. A. Bielz contends that this bird "lives in the broad plains, often in large flocks, generally near Orăştie, Turda and other towns, but also close to the Town of Sibiu, nesting there, as well' (p. 110). In 1884, in Transylvania and Banat, a number of 57 birds were hunted in the counties of Arad – 31, Bihor – 1, Braşov – 2, Caraş – 10, Satu Mare – 2, Sălaj – 2 and Timiş – 9 (Olteanu, 1934). Also in the lowlands of eastern Bucovina, the Great Bustard did exist before 1900 (Grigorovitza, 1908).

In the early 20^{th} century, the Great Bustard numbered about 5,000 individuals in the present territory of Romania (Munteanu, 1986).

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In 1874, Cornescu mentioned "still very many Great Bustards" in the counties of Vlaşca, Teleorman, Romanaţi and "particularly" in Ialomiţa (p. 132). In 1897, Georgescu noted the presence of "large Great Bustards flocks" (p. 268). Munteanu pointed out that, in 1907, the species was widespread in the West Plain, the effective amounting to "at least 1,300 specimens" (1979, p. 155).

However, beginning with the end of the 19th century, cynegetic and faunistic publications would draw attention to the diminution of some animal species, the Great Bustard being among them. As a matter of fact, until 1920, "the situation of this bird was not yet hopeless" (Nedici, 1940, p. 718).

Before the First World War, large numbers of Great Bustards occupied much of the Bărăgan Plain and Central Dobrogea (Cotta, Bodea, 1969). In 1924, Rosetti-Bălănescu affirmed that "numerous Great Bustards still exist" in Moldavia, Muntenia (Walachia), Dobrogea and southern Bessarabia (pp. 212–213). The following year, Cornescu spoke of lots of Great Bustards in Bessarabia, Dobrogea, the Bărăgan and Burnas Plains, as well as on the edge between Vlaşca, Argeş and Teleorman counties. Also Cornescu wrote: "I have many times seen Great Bustards flying over Bucharest, from west to east (in October)" (1925, p. 66). In the first part of the inter-war period the species disappeared from Transylvania.

Subsequently, it became clear that: "the number of Great Bustards is seen to decrease ever more by the year. This sad reality is obvions particularly on the Bărăgan side of Ialomiţa County and in the lowlands of Dobrogea, where one may go scores of kilometres in the most beautiful steppe regions without meeting any Great Bustard" (Revista Vânătorilor, 1936, No. 5, p. 1).

"Roundabout 1930–1935, the numerical and territorial decline of the Great Bustard was already an accomplished fact" (Munteanu, 1986, p. 2). Although "the bird did not bother anyone" its disapperance was "dramatic", said Botezat in 1944 (p. 224).

In 1939, "the richest region populated with Great Bustards was Dobrogea. Part of the Ialomiţa birds winter in Dobrogea", noted Comşia (1939, p. 107), but "many of them are coming in winter from the Russian steppes, being chased by the Crivăţ wind" (Vasiliu and Rodewald, 1940, p. 89). In 1946, Călinescu warned that Great Bustard specimens "kept decreasing" (p. 81); in 1947, Cotta said that the species was "seriously endangered by the intensification of crop cultures also in the central Bărăgan Plain" (p. 11).

In 1949, "large numbers" of Great Bustards existed in the Olt, Teleorman, Vlaşca, Brăila counties and in Dobrogea. "Fairly often" they could be seen in the counties of Arad and Bihor, "new flocks, yet not that numerous as in the past, started coming" to Ialomiţa County (Rudescu, 1950, p. 9).

In the south of Dobrogea "large flocks use to come in winter from the former Socialist Republic of Moldova, especially when the Crivăţ wind is blowing, flying across the Danube Delta to shelter southward from the cold winds" (Rudescu, 1950, p. 9). In March they would flow back north across the Danube Delta, or along the Black Sea coast. Also from Ialomiţa County birds would often fly in winter to Bulgaria and return in springtime.

In 1940–1950, half the national effective of the species lived in Dobrogea (Filipaşcu, 1976). After 1950, Great Bustard populations kept decreasing (no more than ca 700 individuals being left in Romania). This situation made Puşcariu in 1952 uphold that "the species was endangered" (p. 27). In 1953, the "Vânătorul" periodical journal wrote, "just by its way of life, the future of the Great Bustard seems rather dim to us" (No. 4, p. 4).

The Great Bustard population dynamics between 1950 and 1996 (Fig. 1) is assessed based on published data (Barbu, 1958, 1962, 1976, 1978, 1980, 1982, 1984; Munteanu, 1979, 2005; Popescu *et al.*, 1961; Stănescu and Popovici–Vigo, 1991; Alaci, 1998; Negruţiu *et al.*, 2000), but more especially on original data found by the author in the archives of some central and local forestry and cynegetic institutions.

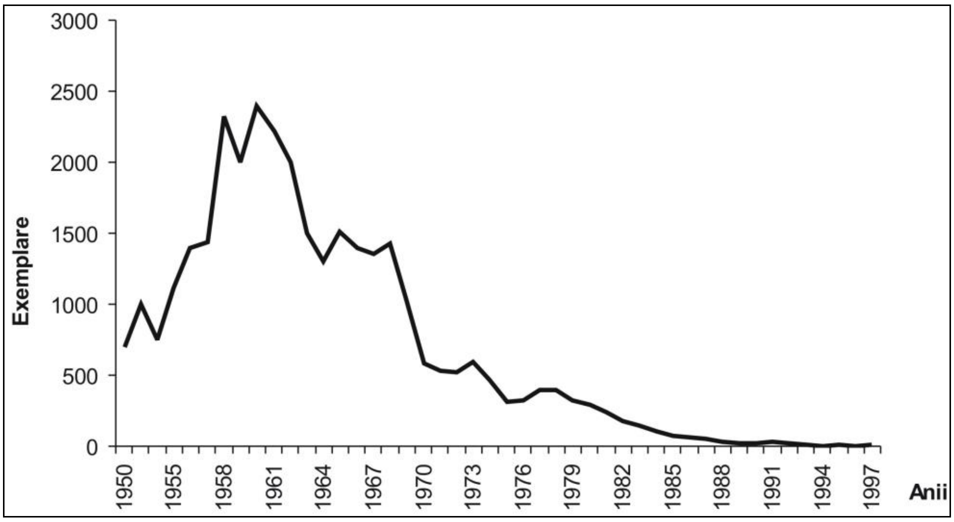

Fig. 1 – The dynamics of the Great Bustard population in Romania between 1950 and 1997 (specimens).

The collectivisation of agriculture and the resumption of big cultures brought about more calm on the ground, favouring the growth of Great Bustard effectives, that trend continuing for nearly ten years (1950–1960), except for 1954, when a heavy February snowstorm destroyed one-fourth of the flock. All in all, the above decade witnessed a 3.4 time increase of the species.

In 1955, the Great Bustard could be seen in 9 of the former administrative regions of Romania (Barbu, 1976, Table 1), most of them in the Romanian Plain (63%), Dobrogea (21%) and the West Plain (16%).

Table 1

Great Bustard effectives by administrative region in 1955 (specimens).

Region	București	Dobrogea	Oltenia	Argeș	Banat	Galați	Crișana	Ploiești	Maramureș
Sp.	310	240	161	130	114	60	50	40	5

On the 1st of April 1957, Constanţa Region had over 500 imdividuals, Timişoara and Oradea some 400 (Barbu, 1958). That same year, Rosetti-Bălănescu recalled, the presence of a flock of 150 birds in Teleorman County.

In the spring of 1958, the effective had 2,320 individuals (Popescu *et al.*, 1961) which, in terms of physical-geographical regions, was proportionally similar to that in 1955 (Table 2). The most numerous Great Bustard population in Romania (2,400 specimens) was registered in 1960, steadily regressing afterwards.

Table 2

Great Bustard effectives by administrative region in 1958 (specimens)

Region	Argeş	Bucureşti	Dobrogea	Banat	Oltenia	Crişana	Galaţi	Maramureş	Ploieşti
Sp.	665	580	505	200	180	140	35	10	5

In 1961, an increase versus previous years was recorded in the former regions of Piteşti and Banat, while Dobrogea registered a decrease (Almăşan, Popescu, 1963). In Bucharest region, the number of Great Bustards in 1967 was half that of 1965, although not even 1% of the effective had been hunted (Barbu, 1968).

In 1968, there were 1,423 birds in Romania (Table 3), the effective having dimished 4.1 times within the 1960–1970 interval. That same year, Rosetti-Bălănescu recalled the presence of a flock of 150 birds in Teleorman County.

Table 3

Great Bustard effectives by county in 1968 (specimens)

County	Olt	Teleorman	Timiş	Arad	Dolj	Brăila	Dâmboviţa	Argeş	Bihor	Ilfov	Ialomiţa
Sp.	840	240	115	110	48	20	10	10	10	10	10

Having in view the Great Bustards limited ecological plasticity and failure to get adapted to new environments “the risk for its disappearance is very great, indeed”, warned Radu in 1972 (p. 55).

In 1978, the species numbered only 401 specimens (Table 4).

Table 4

Great Bustard effectives by county in 1978 (specimens)

County	Teleorman	Olt	Timiş	Arad	Bihor	Dolj	Ilfov
Sp.	134	114	96	33	10	8	6

Over a lapse of ten years (1971–1980) the population dropped by 45%, and by 14 times, between 1980 and 1989.

In 1990, there were 109 times fewer birds than in 1960, under 20 after 1992 (1993: 9 in Timiş County and 2 in Olt County), eventually becoming simply a symbolic species. Noteworthy, mild population increases were registered in 1965, 1973 and 1977 compared to the previons years, due largely to greater local protection of the species.

Between 1974 and 1986, most specimens lived in the counties of Teleorman, Olt and Timiş, the largest Great Bustard presence (until 1996) occurring in Timiş County.

With human activities progressing in the Great Bustard`s territories, the species population dynamics registered steep numerical decreases in the 1980s, only 20–30 individuals being left in 1991 (Almăşan) and no more than 15 in 1994 (Weber *et al.*); the last specimens were oficially registered in 1997.

Until 1997, the Great Bustard had been a stable species in Romania.

Later on, erratic specimens would appear in all the months of the year. Solitary individuals, or small unstable flocks, were observed over longer or shorter periods of time in various places.

The past few years witnessed them near the western frontier (Bihor and Timiş counties), having arrived temporarily from Hungary and Serbia. Occasionally, there were years when the bird would fly from the Ukraine into Dobrogea and Muntenia (Walachia).

This confirmed Barbu’s finding in 1982: “If the Great Bustards decline went on at this rate, the situation would shortly be alarming, so that seeing any bird around the year 2000 would be quite an exception” (p. 10).

In the inter-war period, the stable population became extinct in Transylvania, in the 1940–1950s in Moldavia, in the 1960s in Dobrogea, in the 1980s in Muntenia, in the 1990s in Oltenia and Banat, being on the “verge of extinction” in Crişana.

3. WHAT CAUSED THE GREAT BUSTARDS NUMERICAL DECREASE?

The cause was man-made, whether directly (hunting, poaching), or indirectly (changing or destroying habitats, land managements, expansion of settlements and warys of communication).

As far back as 1874, Cornescu warned on the disappearance of the species in Romania.

Manu would even state that Great Bustards are “horified by the presence of man” (1927, p. 211). Intense human activity steadily altered and narrowed down the area in which the bird lived, numbers decreasing. What man did was to reduce its vital area.

In the last 150 years, the steppe vegetation would permanently make room for agriculture (primarily by fallowing natural meadows and turning them into arable land). “Turning the steppe into agro-systems was not detrimental to this species which did easily adapt itself to this new type of habitat” (Munteanu, 1979, p. 158).

Before 1920, great estates proved favourable habitats, because “once the soil was ploughed and sown, the birds could live almost undisturbed until harvest time, they could lay eggs, hatch them and raise the young. But things would change following the Land Reform made after the First World War; wheat and maize crops, alternating almost everywhere in the fields, meant continuous and varied agricultural works, basically the permanent presence of people, cattle and dogs in the field from snowmelt to the end of May, just the time when Great Bustards start hatching” (Manu, 1927, p. 211).

Not only was the quiet of their habitat disturbed, but in many regions the locals would find their nests, collect the eggs and eat them. Even the young, which could not yet fly, would sometimes be captured.

Neither the inter-war restrictions imposed by the Hunting Direction (e.g. shorter hunting season, exclusively bullet-hunting, banning the catching of the bird on glazed soil) had any effect.

In the first 20-century decades, overhunting and poaching diminished the population.

Initially, hunting was an all-year activity, it affecting both sexes. Intense poaching on glazed soil had “devastating” consequances for the bird (Călinescu, 1946, p. 96). Poaching was going on even at night, poachers using tractor headlights (e.g. in Ialomiţa County).

The collectivisation of agriculture (hence big crop cultures) helped for a time the population to recover (there was quiet and food), but once it acquired an intensive character (through mechanisation and chemicalisation), the population would again decline, this time irreversibly.

Agriculture, increasingly more mechanised and chemically fertilised after 1960, deeply altered the Great Bustard`s habitat, destroying its eggs and the young in the nest. Before 1955, over 95% of the land was cultivated by hand and driven by animals, fertilisers being exclusively of biological origin. Tractors and agricultural machines affected the nests and the young that did not yet fly.

Chemicals reduced the agro-systems’ trophic potential (destroying the spontaneous flora and the invertebrates, primarily the insects), so that Great Bustards could hardly get the necessary food, weakening their organisms and depleting their fertility.

At the same time, hoenig cultures (especially maize after 1880) were extended, but the Great Bustard could not get accustomed to the maize crop, so the effective diminished.

Intense grazing in the lowlands contributed both indirectly (by destroying hatching nests and the young deserted by the adults), and directly (by the presence of shepherd dogs).

The increasing human population, the creation of new villages in the lowlands and the expansion of existing ones were other factors that depleted the number of birds.

In the 19^{th} century, the Great Bustard`s area was fragmented by the extension of the railway network; in the 20^{th} century, it was modernised and intensified road-and-rail circulation that did it. Constructions and/or installations that covered the bird’s habitat (farms, silos, enterprises) made it eventually leave its territories. Even the noise produced by air flights, when spreading chemicals on cultivated grounds, had a negative impact. The planting of forest belts (in the 1950s), the expansion of drilling-and-draining works and irrigation works in the 1950–1980s) in areas where Great Bustards still lived affected their habitat (irrigations producing a humid microclimate improper for the young).

In addition, the species was little prolific (1–2, very seldom 3 eggs/year), fragility of the chicks were fragile in the first days following ecclosion and more sensitive to cold in the humid and cold spring time. The low proportion of males (caused by overhunting), bence depleted birth-rates had a negative impact on the Great Bustard populations.

A lesser influence had the foxes, badgers, stray dogs, or the shepherd dogs which used to catch the eggs and the young when the female had left the nest (in search for food, or whenever disturbed), accidents caused by the electricity network (e.g. in Teleorman, Olt and Giurgiu counties), noise pollution (due to the mechanisation of agriculture and greater road-and-rail circulation) (hence, more and louder noise) and not least, the exploitation of some natural resources (hydrocarbons).

The man-made changes in the lowland ecosystem prevented the Great Bustard “from adjusting its ancestral way of life fast enough, the bird being endangered as early as the egg stage”, considered Alaci (2009, p. 21), moreover “it cannot get adapted to the progress of civilisation and human population increase” (Cotta, 1973, p. 104).

As a species, the Great Bustard was in a difficult situation, despite the female decennial status of monument of nature.

The data presented in this paper illustrate a case of reduced biodiversity in Romania.

4. CONCLUSIONS

An anthropophobic bird, very cautious and vigilent, the Great Bustard has been one of the species most seriously affected by human activity. Whereas in early 20th century it could be seen in the lowlands and in some low tablelands of all the Romanian provinces, later on its area kept shrinking, and getting increasingly more fragmented.

The species` effective would decrease numerically in the four decades of the 20th century.

The 2.8 time increase (from 700 to 2,400 individuals) between 1950 and 1960 was followed by steady decreases down to 1,500 specimens in 1963, 1,400 (1966), 1,030 (1969), 590 (1973), 401 (1978), 239 (1981), 104 (1984), 30 (1988), 11 (1993) to no more than 6 individuals in 1997. While a numerous presence in the lowlands of Romania in the early 20th century, seven decades later it was found in 11 counties (1968), then in seven (1978), becoming a stable zoo-element in two counties (1993), and eventually in one county alone (1997).

In our opinion, the Great Bustard was a stabile species in Romania’s fauna until 1997, subsequently solitary, or small unstable flocks of birds would occasionally appear near the west frontier (flowing in from Hungary, less so from Serbia), and in the south of Romania (coming from the Ukraine).

Today, the Great Bustard is extremely rare (on the verge of extinction) in this country, the last small area where the species is occasionally seen is west Salonta (Bihor County), individuals originating from populations in Hungary.

The Great Bustard falls into the category of relict species (Drugescu, 1994), critically endangered (Munteanu, 2005).

What has primarily led to its disappearance is the excessive human presence in its original habitat and poaching. Other causes: very low reproduction rate, sexual maturity at late age, and the hunting of the most vigorous cocks, thus producing the genetic degradation of the species.

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SPATIAL ANALYSIS OF ENVIRONMENTAL AND ANTHROPOGENIC INFLUENCES ON NITRATE CONCENTRATION IN SHALLOW GROUNDWATERS. CASE STUDY: RUSCOVA VALLEY, MARAMUREŞ MOUNTAINS (ROMANIA)

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Key-words: nitrate, shallow groundwater pollution, spatial analysis, Ruscova Valley, Maramureş Mountains.

Abstract. In many rural areas of Romania groundwaters stand out as the main sources for water supply. As a result, the assessment of the shallow aquifer of Ruscova Valley (Maramureş Mountains) is an important research direction since the nitrates are considered some of the major causes of deteriorating water quality, with influences on the human health. The outcomes of this paper relied on data collected from field surveys (water samples) combined with Geographical Information Systems (GIS) and statistical assessment of the existing and derived spatial data. In addition to nitrate concentration, determined in 26 water samples, several parameters were measured during the field surveys: water *pH*, temperature, depth to water and altitude of the sample point. Moreover, several environmental and anthropogenic potential explanatory factors for nitrate concentration were analysed: depth to water, land use/land cover, lithology, soil texture, number of households and population density. In order to reveal the relationship between the nitrate concentration and this explanatory factors the authors used a multiple linear regression (MLR). Spatial and statistical analysis were realised for three buffering zones (100 m, 200 m, 300 m) created around each water sample in order to identify and quantify the role of the explanatory factors at various scales. Finally, through regression analysis it was possible to determine which datasets explain better the nitrate concentration in the shallow groundwater.

1. INTRODUCTION

In comparison to surface water, groundwater has been considered as an important source of water supply due to its relatively low susceptibility to pollution and its large storage capacity (U.S. Environmental Protection Agency (USEPA), 1996). Diffuse nitrate pollution of groundwater is currently considered one of the major causes of deteriorating water quality (Knapp, 2005), thus becoming a widespread environmental issue affecting all countries regardless of their level of economic development (Tagma *et al.*, 2009).

Nitrate groundwater pollution is currently increasing and often recognized to be a threat to health of living beings which depend to this type of water resources. Because of their solubility and low binding capacity, nitrates' capacity to migrate to shallow aquifers and groundwater favours their persistence in polluted water until consumed by plants or other organisms. Excessive amounts of nitrate can cause a blood disorder-methaemoglobinaemia, commonly known as infant cyanosis or "blue-baby syndrome" which leads to a reduction of the oxygen caring-capacity of bloodstream. The most exposed to this disease are infants under 1 year of age. In epidemiological studies, derivation methaemoglobinaemia was not reported in infants in the areas where drinking-water consistently contained less than 50 mg/L (World Health Organization (WHO), 2004). Moreover, the coupling of nitrates with amines, through the action of bacteria in the digestive tract, may result in the formation of nitrosamines, potential related to cancer risk (Bell, 1998).

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The natural nitrate concentration in groundwater under aerobic conditions is a few milligrams per litre and depends strongly on soil type and on geological settings. Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures) from wastewater treatment and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks (WHO, 2011).

According to the WHO (2011) guidelines for nitrate, the maximum acceptable concentration of nitrate for potable water is 50 mg/L for a short-term exposure, and represents the reference values in the development of national standards. In few states, i.e. Italy, a limit of 10 mg/L NO_3^- has been recommended for drinking water destined to infants. Also, the USEPA (1995) has established a drinking-water standard of 10 mg/L nitrate-nitrogen (equivalent to 10 ppm nitrate-nitrogen or 45 ppm nitrate) based on the human health risks due to nitrate consumption. The Nitrates Directive 91/676/EEC (European Commission, 1991), developed in response to the European Union's concern about the environmental and health implications of this phenomenon and the EU Water Framework Directive 2000/60/EC (European Commission, 2000), stressed the need to reduce water pollution caused by nitrates from agricultural sources to 50 mg/L nitrate concentrations in water bodies. The same threshold was established by the Romanian Government Decision no. 964/2000 (Romanian Government, 2000) for the approval of the Action Plan for the water protection against pollution with nitrates from agriculture sources and by the Law 458/2002, modified by Law 311/2004 (Romanian Government, 2004) on the quality of drinking water.

2. STUDY-AREA

The study-area is located in the Maramureş Mountains, including the lower part of Ruscova Valley and its main tributaries (e.g. Repedea, Cvasniţa) (Fig. 1). Furthermore, the area is part of Maramureş Mountains Natural Park (Category V IUCN – Protected Landscape-Natural Park), overlapping, in terms of Park zoning, the sustainable development and sustainable management areas.

The study-area covers 1,230 ha with altitudes decreasing from 620 m to 410 m. Generally, the relief is represented by floodplain and fragmented terraces (formed in the Cvasniţa – Ruscova and Ruscova – Vişeu confluence areas). In terms of geological features, the area corresponding to Poienile de sub Munte and Ruscova Depressions was formed within the Paleogene Gulf (Posea *et al.*, 1980). Largely, the rock types belong to sedimentary formations (including sands, gravels, sandstones, conglomerates and marls), covered by fluvisols, dystric and eutric cambisols. After the hydrogeological map of the Geological Institute of Romania, 1969, 1:1,000,000 scale, the considered shallow aquifer lies in the aquifers systems hosted within the sandstones and marls (Eastern Carpathian Flysch). According to the Climatic Regionalization (Bogdan, 2002), the area displays a moderate continental climate with Atlantic humid influences. The multi-annual air temperature means vary between 5°…6°C in the eastern part and 7°…8°C in the extreme west of the area. As in the case of temperature, the quantity of precipitation is unevenly distributed within the area. The multi-annual mean is estimated between 1,000 – 1,100 mm in the eastern part and around 900 mm in the Ruscova – Vişeu confluence area.

There are three administrative-territorial units (Poienile de sub Munte, Repedea, Ruscova) with about 21,000 inhabitants (2014) (http://statistici.insse.ro/shop/). The main land-use category is represented by agricultural land, including arable lands and orchards, frequently developed near the built-up areas. The households are spread close to the main roads, and in the central parts of localities. Agriculture and animal breeding are the most significant activities carried out in this area.

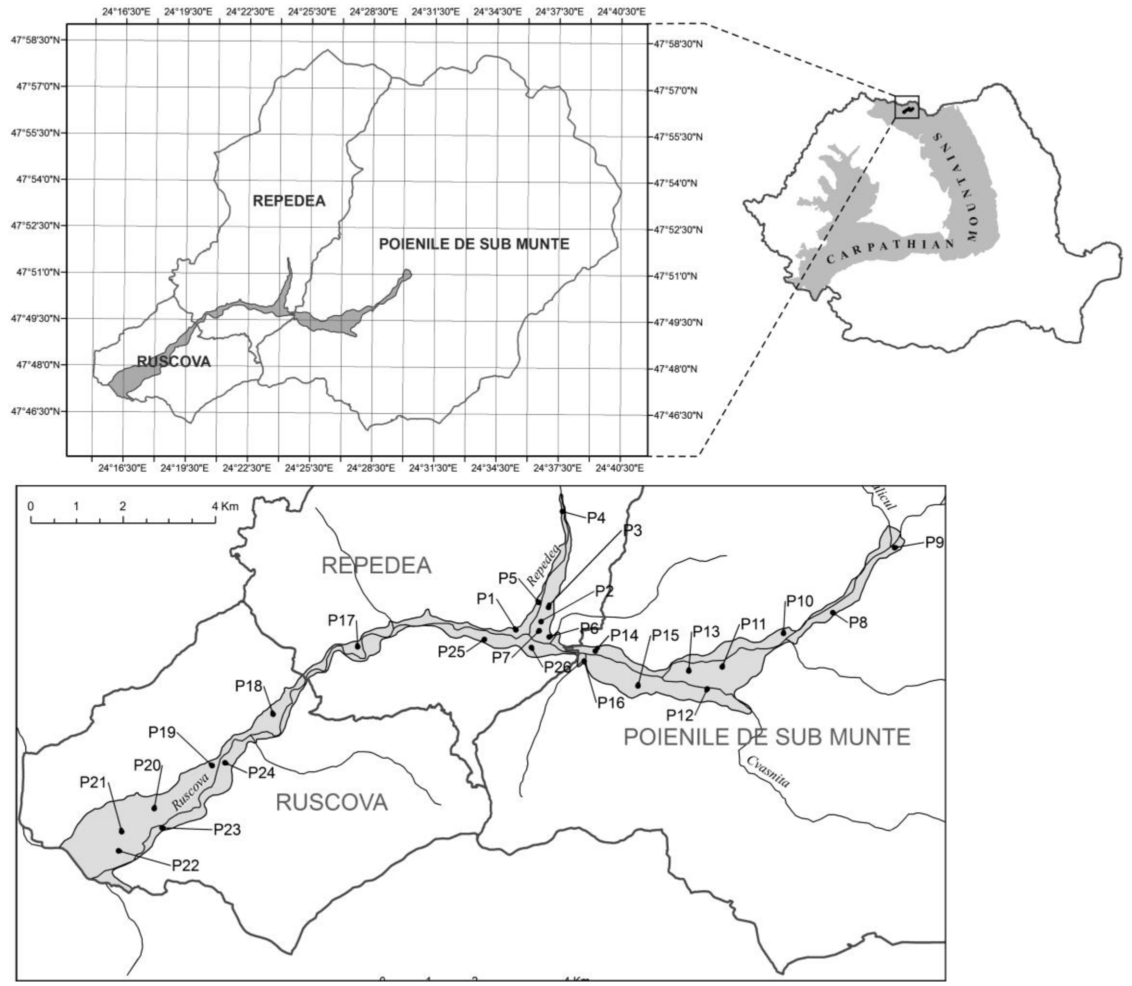

Fig. 1 – Location of the study-area.

In the study-area, groundwaters still represents the main drinking water sources. Although there is connection to water supply system, local communities often use the individual wells linked to shallow groundwater.

3. METHODS

3.1. Field sampling

In the spring of 2014, in Poienile de sub Munte, Repedea and Ruscova localities the nitrates content was determined *in situ* in 26 water samples from domestic wells. Additionally, several parameters were measured in the field: depth to water, water *pH*, water temperature and sample altitude (Table 1). Nitrate concentration was determined using nitrate-test strips *(MQuant^{TM} Nitrate Test, Cat. No. 1.10020.0001, E. Merck, Darmstadt, Germany)*, a quick analysis instrument based on the visual comparison of the reaction zone of the test strip with the colour scale indicated on the box. Water *pH* and temperature were determined using the *WTW Multi 340i* handheld measuring instrument. The position of each water sample site was recorded using a GPS system.

Table 1

The measured indicators for water samples

Sample code	Location	NO_3^- (mg/L)	Depth to water (m)	Temperature (°C)	pH	Altitude (m)
P1	Repedea	40	3.5	12	7.5	500
P2		70	4.0	8	7.9	509
P3		10	6.0	11	7.5	512
P4		15	12.0	12	7.7	547
P5		30	7.0	8	7.8	511
P6		20	3.0	15	7.7	505
P7		40	7.0	16	7.2	504
P17		50	4.0	9	7.8	476
P25		<10	8.0	10	7.9	496
P26		<10	5.0	10	7.8	506
P8	Poienile de sub Munte	10	6.0	9	7.8	579
P9		25	7.0	9	7.7	604
P10		30	8.0	12	7.1	570
P11		15	12.0	12	7.5	549
P12		<10	15.0	10	7.6	545
P13		<10	16.0	13	7.8	539
P14		15	8.0	9	7.7	514
P15		<10	4.0	9	7.4	529
P16		<10	12.0	8	8.1	522
P18	Ruscova	20	7.0	10	7.9	457
P19		40	10.0	9	7.4	441
P20		50	12.0	10	8.1	434
P21		25	18.0	11	7.8	426
P22		70	18.0	11	7.3	424
P23		<10	18.0	11	7.8	422
P24		40	5.0	10	7.8	443

3.2. Spatial and statistical analysis

Environmental and anthropogenic explanatory factors

Given the geographical conditions, human activities and land use, the current findings revealed that in the study-area the shallow groundwater is polluted especially as a result of farming activities and human waste.

In order to assess the nitrate concentration in the shallow groundwater and its relation with the explanatory factors several spatial data, including both environmental and anthropogenic factors, were used: depth to water, slope declivity, land use/land cover, lithology, soil texture, number of households and population density (Table 2). The data was considered according to 100 m, 200 m, and 300 m buffers surrounding each well. The resulted data were analysed using statistical regression analysis. Different multiple linear regression models were created for each buffer depending on size. The results were used to determine how each explanatory factor can influence the nitrate concentration in the shallow groundwater at different scale.

Depth to water (DW) was determined by measurements of local water level in the shallow wells/hand pumps. *Land use/land cover* data derived from the orthophoto images, scale 1:5,000, classified into four classes according to their potential influence on nitrate concentration: areas mostly occupied by *built-up areas* (BA), areas mostly occupied by *arable lands* (AL), areas mostly occupied by *grasslands* (GRASS) and *others* (OTH), including forests, shrubs, water courses, alluvial deposits and bare soils. *The slope declivity* (SD) was determined by TIN (Triangulated Irregular Network) surface model created by counter lines extracted from the topographic map, 1:25,000 scale. The *population density* (PD) was calculated based on TEMPO Online database, at built-up areas level. The *number of households* (HN) was extracted and calculated based on orthophoto images, scale 1:5,000. This indicator is important since includes isolated houses or stables outside the built-up areas (within arable lands and/or grasslands). The data referring to *lithology* (LITHO) and *soil texture* (TEXT) was extracted from the geological and soil maps, respectively (scale 1:200,000). In order to carry out the spatial and statistical analysis, these maps were coded according to their classes (Table 3).

Table 2

Explanatory factors used to assess the nitrate concentration in the shallow groundwater

Data layer	**Source / comments**
Depth to water, in meters (DW)	terrain records; measurements of water level in shallow wells/hand pumps
Slope declivity, in degrees (SD)	TIN (Triangulated Irregular Network) – surface model; derived from the topographic map, scale 1:25,000
Land use/land cover	derived from the orthophoto images, scale 1:5,000; divided in 4 categories
Lithology features (LITHO)	extracted from the geological map, scale 1:200,000 (Geological Institute of Romania); divided in 5 categories
Soil texture (TEXT)	extracted from the soilo map, scale 1:200,000 (National Research & Development Institute for Pedology, Agrochemistry and Environment Protection); divided in 3 categories
Number of households in the defined area (NH)	derived from the orthophoto images, scale 1:5,000
Population density, number/defined area (PD)	Calculated by National Institute of Statistics; reported at built-areas level (LAU 2)

Table 3

Lithology and soil texture categories extracted from the geological and soil maps

Description	**Code**
Phyllites, sericitous-chloritous schists	LITHO1
Gravels, sands and loess-like deposits	LITHO2
Micaschists, Paragneisses	LITHO3
Sandstones, marly clays, marls, sandstones (flysch)	LITHO4
Bituminous shaly clays and siliceous sandstones	LITHO5
Varied texture	TEXT1
Loamy	TEXT2
Loamy-sand…loamy-clay	TEXT3

Quantifying spatial data

The spatial analysis of the environmental and anthropogenic influences on nitrate concentration in shallow groundwater was undertaken for three buffering zones (Fig. 2), shaped around each water sample: buffer = 100 m (3.14 ha), buffer = 200 m (12.56 ha) and buffer = 300 m (28.26 ha). This approach is aimed at identifying and quantifying the influence of the explanatory factors around each water sample at various scales. Furthermore, the buffer zones were chosen in order to determine which datasets explain better the nitrate concentration in the shallow groundwater through regression analysis.

Excepting the depth to water, which remained the same, all explanatory factors were calculated using zonal statistics account. Thus, the percentage of each category of land use, lithology and soil texture was determined depending on the buffer area. *The slope declivity mean* was calculated as Weighted Arithmetic Mean within each specific buffer. *The number of households* was determined depending on the number of units within each specific buffer. Similarly was determined the *relative population density* in each specific buffer, depending on the total number of habitants and built-up areas within each locality in the study-area.

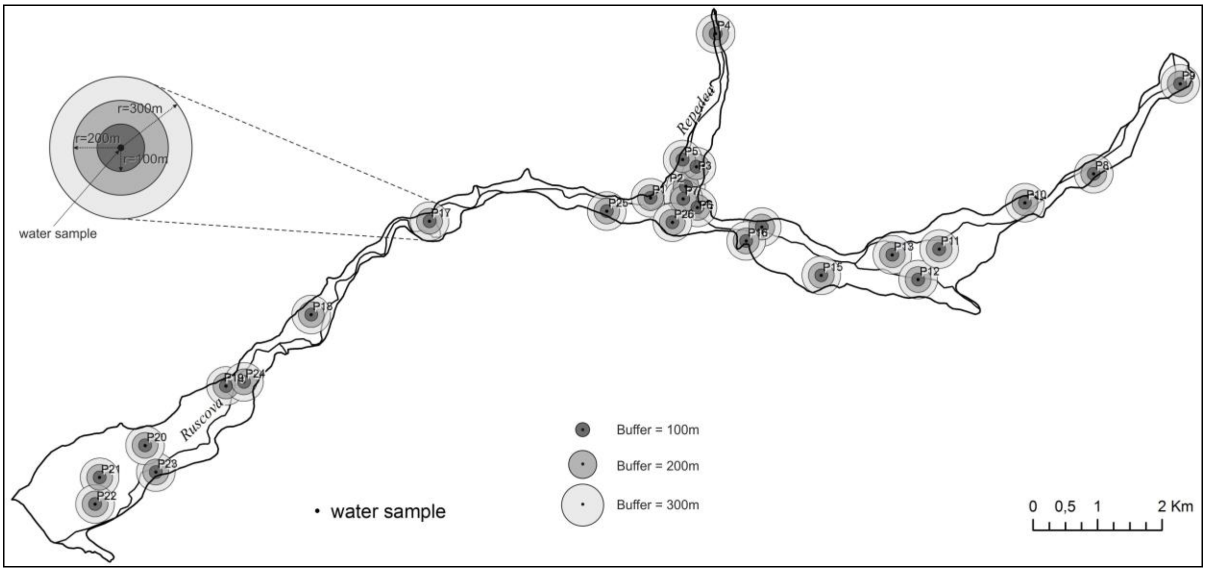

Fig. 2 – Water samples with 100 m, 200 m and 300 m buffers.

Statistical analysis

Data normalization. For the statistical analysis, all data (including nitrate concentration) were normalized into the range 0…1. Normalization was done by *Min-Max linear transformation* of the input data in order to achieve similar data range (Eq. 1).

$$N = (X-X_{min})/(X_{max}-X_{min}) \quad (1)$$

where N = normalized data (0…1); X = the dataset; X_{min} = minimum value from the dataset; X_{max} = maximum value from the dataset.

Multiple linear regression models. For estimating the correlation between the independent variables and the nitrate concentration in shallow groundwater the multiple linear regressions (MLR), performed using SPSS statistical software package (Statistical Package for the Social Sciences), was applied. The aim of this paper was not to obtain a model which describes nitrate level in the study-area, but to test the importance of different factors on nitrate pollution. For this reason, all the selected explanatory factors were included in this analysis.

NO_3^- values were used as dependent variable and DW, SD, BU, AL, GRASS, OTH, LITHO1, LITHO2, LITHO3, LITHO4, LITHO5, TEXT1, TEXT2, TEXT3, NH, PD as independent variables. MLR was performed using backward method (stepwise elimination) until only those which were significant ($p < 0.05$) were maintained in the models. Moreover, models were created for each of the three different buffer sizes defined for the current study.

The standardized beta coefficients *(ß)* were used by determining the relative influence of the analysed independent variables on nitrate concentration. For statistical tests, the following interpretation of p values was used: $p < 0.05$ = significant, $p < 0.01$ = highly significant, $p < 0.001$ = extremely significant, $p > 0.05$ = not significant.

4. RESULTS AND DISSCUTION

4.1. The water sample indicators

The samples show that the shallow groundwater temperature during the sampling campaign varied between 8 and 16°C, with highest values within populated areas. The *pH* values fall into the neutral-alkaline range, with highest values in P16, P20, P2 and P18. Generally, the nitrate concentration values are below 50 mg/L, ranging between <10 and 70 mg/L: 17 samples exceeding 10 mg/L and two 70 mg/L (Table 2).

The highest nitrate concentration (≥50 mg/L) was identified in individual fountains (P2 and P17 – Repedea) and public fountains (P20 and P22 – Ruscova). Here, depth to water varies between –6 and –8 meters. According to the specific buffers, the environmental conditions show sedimentary rocks (gravels, sands) covered by soils with varied textures. The foremost land use categories are represented by built-up areas and arable lands.

Lowest values (≤10 mg/L) were identified in wells/hand pumps in Paleogene rocks (sandstones, marls, marly clays) mainly covered by soils with loamy and loamy-sand…loamy-clay texture. Here, the main land use/land cover categories are grasslands and forests or shrubs.

4.2. Spatial variability of nitrate concentration

The spatial variability of nitrate concentrations in the shallow groundwater of the study-area was obtained using a simple interpolation method: IDW (Inverse Distance Weighted). The map (Fig. 3) indicates increasing values from upstream to downstream of the Ruscova Valley, where the built-up areas and arable lands are more extended. The lowest values were spatialized in the eastern half (approx. 10-20 mg/L), with a minimum in Poienile de Sub Munte locality. The highest values of nitrate concentration are specific for Ruscova locaity, with maximum values near the Ruscova–Vişeu rivers confluence area (50-70 mg/L).

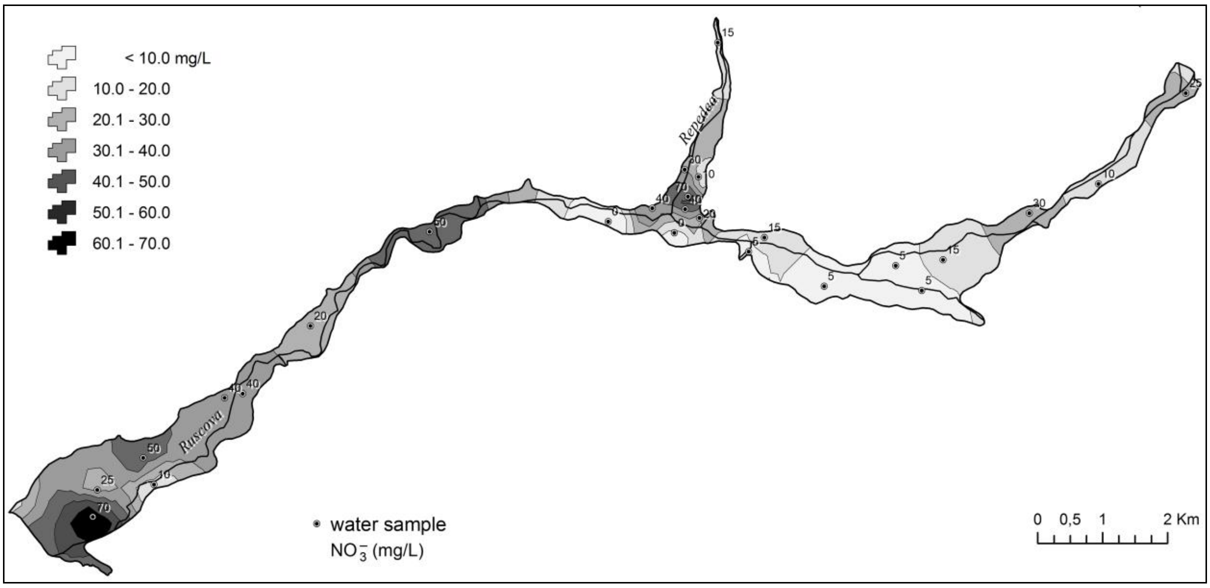

Fig. 3 – NO_3^-concentration in the shallow groundwater.

Generally, the mean NO_3^- value within the study-area, calculated as *Weighted Arithmetic Mean*, is 30.0 mg/L, with differences between localities: 17.0 mg/L in Poienile de sub Munte, 33.0 mg/L in Repedea and 42.0 mg/L in Ruscova.

4.3. The influence of the analysed explanatory factors on nitrate concentration

In this study-area, the content of nitrates in the shallow groundwater can be explained only relying on both environmental and anthropogenic factors. The different values resulted from the regression models applied for the three different buffer zones explained how different variables could become statistically significant at various scales (Table 4).

Table 4

Results of multiple linear regressions (coefficients *ß)* at different scale

Independent variables	buffer zone = 100 m	buffer zone = 200 m	buffer zone = 300 m
DW	x	x	x
TOPO	x	x	0.738^{*}
LITHOcateg.1	x	2.538^{***}	x
LITHOcateg.2	x	4.254^{***}	x
LITHOcateg.3	-0.67^{*}	2.320^{***}	x
LITHOcateg.4	x	3.023^{***}	x
LITHOcateg.6	x	x	x
STcateg.1	x	x	x
STcateg.2	x	x	-0.759^{*}
STcateg.3	x	x	-0.955^{**}
BU	14.576^{**}	x	1.115^{*}
AL	20.668^{**}	x	x
GRASS	14.734^{**}	x	x
OTH	x	x	x
PD	-2.198^{*}	x	0.894^{*}
NH	x	x	x

*** $p < 0.001$ = extremely significant; ** $p < 0.01$ = highly significant; * $p < 0.05$ =significant;
^{x} $p > 0.05$ = statistical not significant

In relation to the number and location of the water samples, the spatial data used and the particularities of the study-area, the multiple regression coefficients indicate the following:

1) The best results in terms of statistical significance were obtained only when all sixteen independents variables were used concurrently in the models. Multiple linear regression results which involved environmental or anthropogenic explanatory factors alone are not statistically significant ($p > 0.05$) for each independent variable. These can explain that the shallow groundwater pollution is a complex process, which depends on both environmental and anthropic factors;

2) At minimum local scale (buffer zone = 100 m), built-up areas and agricultural activities have a strong influence on nitrate concentration (BU = 14.58, AL = 20.67; GRASS = 14.73). These can be explained because the analysed water samples are generally located within populated areas, where these land use categories prevail. The regression coefficient of PD (-2.198) indicates a low inverse relationship between population density and nitrate concentration explained by the reduced number of inhabitants within specific area (mean = 94.2);

3) At medium scale, buffer zone = 200 m, agricultural activities (AL = 10.71) and build-up areas (BU = 6.28) have a strong influence on the nitrate concentration. Also, a direct influence of lithology on nitrate contents was noticed. Thus, the regression coefficients indicated a decreasing in NO_3^- values depending to the rock's permeability;

4) At maximum scale used in present study (buffer = 300 m), the highest values from the dataset indicated a direct influence of BU (1.12) and PD (0.89) on NO_3^- concentration. This can be explained by the extent of the built-up area and the high number of inhabitants in the analysed buffer (mean = 394.2). Moreover, the SD has direct influences on nitrate contents, indicating that NO_3^- tended to be high when the mean slope gradient increased. This can be explained by the topographic characteristics which are favouring the nitrate accumulation.

5) The DW (depth to water), LITHO5 (bituminous shaly clays and siliceous sandstones), TEXT1 (soil varied texture), OTH (forests, shrubs, water courses, alluvial deposits and bare soils) and NH (number of households) are not statistically significant ($p > 0.05$) for all buffer sizes. This means that these independent variables cannot explain nitrate concentration in the shallow groundwater at these defined scales.

6) Finally, the regression coefficients indicate changes in the number of explanatory factors and their influence on nitrate concentration, depending on buffer zones. In other words, anthropic factors tended to be more important as the distance to wells/hand pump decreased. Thus, the results highlighted that the model associated with 100 m buffer displayed land use as the explanatory factor with the strongest influence. As the distance increases, the environmental factors tend to become more important. The results for 200 m and 300 m buffer indicated the importance of soil texture and especially lithology which proved to be statistically highly significant ($p < 0.001$).

4.4. Uncertainties of data

Based on the researches carried out for the current study and the resulted outcomes, some limitations and assumptions have to be pointed out:

The number and homogeneity of water samples. The dataset include only 26 water samples, inhomogeneously distributed over a surface of 1,230 ha. This can be explained because in some cases the access to the private wells/hand pump was restricted. Also, for certain households, the water sources are represented by artesian springs, located in the nearby slopes.

The determination method of nitrate concentration. Nitrate concentration in the water samples was determined using nitrate-test strips. In this case, in comparison with the laboratory results, these values are considered approximate.

The period of the vegetation period when the samples were determined. Nitrate concentrations in the shallow groundwater can vary substantially depending on vegetation season. Groundwater pollution studies indicate that trees and plants may temporarily store large quantities of nutrients during the growing season for release to aquifers during subsequent nongrowing season (Walker, 1973). Thus, we can deduct that during the nongrowing vegetation period the nitrate concentration in the shallow groundwater can be slightly higher.

Therefore, the current approach should be used as a preliminary study concerning the nitrate concentration in the shallow groundwater in relation to its main explanatory factors.

5. CONCLUSIONS

The current study refers to the assessment of the shallow ground water quality within a rural area located in Maramureş Mountains focused on the nitrate concentration and their environmental and anthropogenic explanatory factors.

The datasets were analysed according to three buffer zones in order to identify and quantify the role of the explanatory factors at various scales, in the buffer zones set around each water sample. Furthermore, multiple linear regressions were used to test the importance of these explanatory factors on nitrate pollution.

In the Ruscova Valley only in few analysed water samples the nitrate concentration values were below 10 mg/L. Frequently, the nitrates concentrations were 10-30 mg/L or higher, indicating the pollution of shallow groundwater due to anthropic activities (including application of fertilizers, human and animal waste, septic tanks). As a result, within the study-area, the nitrate concentration varies, registering lower values in the eastern half (10-20 mg/L), and higher values near the Ruscova–Vişeu rivers confluence area (50-70 mg/L).

According to the statistical results, the shallow groundwater pollution represents a complex process which depends on both environmental and anthropogenic factors. The greatest correlation coefficients (max. 14.734), with *p* statistically significant (< 0.05) were obtained when the regression models involve all sixteen independent variables. Therefore, regression models applied at buffer zones indicate that anthropic factors tended to be most important close to wells/hand pumps. However, as the distance increase, the environmental factors tend to become more significant.

Given that the increase of nitrates concentration in shallow groundwater may be also influenced/triggered by other factors, a future study aimed at including the quantitative data concerning fertilizers used in agriculture, the number of livestock farms, the number and proximity to stables, the number and location of latrines and septic tanks etc. which can explain better the nitrate pollution in this area.

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EU 'DEEP' PERIPHERY: A CASE STUDY OF MOUNTAIN BORDERLANDS IN BULGARIA

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Key-words: regional development policy, EU deep periphery, mountains, borders.

Abstract. Geographic research and constant monitoring of EU periphery and its dynamics are necessary to identify and outline priority areas for regional development policy. This work proposes that "deep" periphery areas form where peripheries of a different geographic nature (physical, economic, political) and scale overlap. The investigation applies GIS-aided mapping and comparative scale analysis to the case study of Bulgaria to identify "deep" periphery areas and affirm that they are disproportionally situated in the mountain regions along the EU external borders. These study results suggest special regional development policy attention to such areas, among which adoption of a Mountain Sustainable Development Strategy for all mountains within the EU geographic space, and, in particular, a Southeast European Convention on Sustainable Development of Mountain Regions.

1. INTRODUCTION

Urban areas are the largest geographic concentrations of human habitation, political, and socio-economic clout, while mountains are the most sizable part of human geography land periphery -27% of the land area, according to the UN Food and Agriculture Organization (2011). Continuing concentration of population in large cities makes the peripheral characteristics of mountain areas ever more pronounced. At the same time, this tendency engenders a number of diverse incongruities in the geography of human societies and raises the need for pertinent regional development policies.

This research continues to explore the relevance of the core-periphery model to human geography with particular focus on the periphery of the European Union (EU). Its ultimate goal, in respect to the EU policy-making, is to suggest that the Union needs a special regional development strategy to recognize and prioritize the "deep" periphery areas, where peripheral characteristics are most intensive. This goal presupposes the resolution of several tasks. First, the investigation should prove the existence and provide an explanation for the formation of "deep" periphery areas. Second, it should confirm that the "peripheries' overlap" paradigm could serve as a tool for the identification of "deep" peripheries and provide information on their structure and characteristics. Third, the investigation will employ the case-study of Bulgaria to present further evidence in support of the argument that mountain areas, especially those situated along its EU South-Eastern external borders should be prioritized in regional development policy-making.

The study methodology will apply GIS-aided map overlays and comparative scale analysis at five geographic scales (NUTS 0 to LAU 1). The economic and the political factors will be analyzed in a comparative perspective on all scales. Different aspects of the political factor will be added to the analysis, like distance from the EU, state, regional, and local cores, and internal and external border location. Physical geography peripheries (e.g. mountain areas, landlocked areas, and land versus sea borders) will also be used as possible periphery determinants. For reasons of volume and space mainly, but also for its own diverse peripheral characteristics, the Bulgaria case-study has been

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selected. The “peripheries’ overlap” paradigm will be used as conceptualization of the formation and structure of the “deep” periphery areas. This methodology enables better territorial targeting of development policy measures and should therefore be of significant value to the practice of regional planning.

2. MOUNTAINS AS “OVERLAP OF PERIPHERIES” AREAS

Mountains, as well as a number of other specific physical geographic features, often serve as political boundaries of countries and/or their internal administrative territorial units. With the increase of altitude, many other physical and human geographic characteristics transform to render mountain areas progressively peripheral in respect to most aspects of human life (Koulov, 2013). Resources are relatively less accessible, while some features, like soil and climate, acquire qualities which make them less favorable for human use. At the same time, mountain areas are disproportionally rich in some resources, like clean water and air, water and wind energy, forests, wild animals, natural and cultural diversity, scenery and a multitude of other natural assets for recreation, tourism, and sports.

Due to altitude-induced transformations, mountain areas are generally sparsely inhabited and lack large urban areas, economic, financial and state-level political centers. Thus, only about 24% of the 194 state capital cities of the world are situated above 600 m a.s.l. In Europe, in particular, such capitals are real exceptions: Madrid altitude (582 to 667 m elevation above the sea) is very close and the very small Andorra la Vella (population 22,256), the political centre of the landlocked microstate of Andorra is located at 1,023 m (Cybriwsky, 2013).

The local population groups in mountain areas are generally more geographically and socially isolated also from one to another. Compared to the rest of the country, they are characterized by a relatively lower standard of living, higher rates of unemployment, and lower access to social services. In parallel, higher elevation areas are more environmentally vulnerable to both natural and anthropogenic hazards (Nikolova, 2001), among which depletion of resources, deforestation, biodiversity loss, poaching, landslides, and forest fires. A significant discrepancy persists between the higher needs for resource protection at global and national scale, and the socio-economic development goals of the local populations (Koulov, 2013). In such areas the economic activity is less diverse, the infrastructure less developed and more capital intensive, while people are generally more dependent on the local resources. In short, the drawbacks for human development in mountainous areas are generally more significant than the benefits, which, in concert with other factors, like border location, foster the peripheralization of such areas.

In principle, peripherality is not exclusive to mountain areas, nor should they be necessarily peripheral in respect to many human activities. However, the comparative analysis of altitude-induced transformations of the different geographic characteristics (e.g., economic, political, social, cultural, environmental) and the increasing peripheralization of mountainous areas from local to global scale leads to the conclusion that, in such areas, different peripheral characteristics often overlap each other.

Koulov (2013) terms the areas of geographic space, where peripheries of a different nature (physical, economic, political, etc.) and geographic scale coincide, “overlap of peripheries” areas. The proposition here is that: a/ “deep”, a.k.a. more intensive, peripheries form in the areas where peripheries overlap, and b/ the overlap of peripheries paradigm could serve as a tool for the identification of such “deep” peripheries and provide information on their structure and magnitude. Such a tool would provide significant insights into the development status and potential of certain areas and, thus, inform and improve regional policy planning and decision-making.

3. EU CORE AND PERIPHERIES: A GEOGRAPHIC SCALE ANALYSIS

The goals of this section are to identify the location and outline the scope of the current EU economic core, as well as its peripheries, and bring evidence in support of the proposition that “deep” peripheries form in the areas where peripheries overlap. For these purposes, the study applies GIS-aided mapping and comparative scale analysis to four geographic scales – from NUTS 0 to NUTS 3 – as defined by the 2013 Eurostat Nomenclature of Territorial Units for Statistics (Eurostat 2015, a). The description of the present economic core of the EU serves as a point of reference for the exploration of its periphery.

A/ EU Core

In his studies of economic development after the Second World War, Brunet (1989) has developed the concept of a West European “backbone”, divided Europe into “active” and “passive” areas, and referred to an urban corridor of industry, services, and excellent transport infrastructure (Brunet 1989). This region continues to attract the main offices of many multinational corporations and important international organizations, including EU and NATO. In 2014, over 75% of the EU population lived in urban areas (World Bank 2014) and the largest of them are still concentrated in and around the so-called European Blue Banana (2011), or European Megalopolis, a discontinuous banana-shaped corridor in Western Europe, stretching from Northwest England through Benelux and Western Germany to Northern Italy, with a population of around 111 million (Brunet 1989). Hospers (2003) calls the Blue Banana one of the world’s highest concentrations of people, money and industry.

This research uses the Purchasing Power Standard (PPS), which makes possible the comparison of purchasing power per inhabitant across the regions of EU Member States that use different currencies and where price levels are different (Eurostat Regional... 2014, 120). In 2011, GDP in the EU–28 was valued at 12,712 billion euro at current market prices, which equated to an average level of 25 100 PPS per inhabitant. The comparative analysis of the 2011 data at the NUTS 0, 1, and 2 scales (Figs 1, 2, and 3) exhibits a noteworthy difference in the shape of the EU core of “rich” regions, characterized by the above EU–28 average level of 25 100 PPS per inhabitant (Credit Suisse... 2013, 17). In the last 20 years, EU core has spread somewhat towards the south to include Northern and part of Central Italy and South-Eastern France. A much more sizeable shift has taken place in the northern and north-eastern direction, where it currently comprises EU-candidate Iceland and EFTA-member Norway which can also be considered parts of the economic geography of the EU core, Southern Ireland, North-Eastern United Kingdom continues through Sweden and Southern Finland to embrace Denmark, West and South Germany, the Netherlands, Northern Belgium, Luxembourg, and Austria. Isolated parts of the core encompass also of parts of Southern United Kingdom, North-central France, and North and Central Spain, which are mostly state capital regions. EFTA-member Switzerland is also a part of the core (Fig. 3).

B/ EU Peripheries

In 2014, the EU produced an estimated Gross Domestic Product (GDP) of 18.124 trillion US dollars, which represents over 20% of the world GDP in terms of Purchasing Power Parity, larger than any country (World Economic Outlook: Legacies, Clouds, Uncertainties (2014), International Monetary Fund). Besides that, in 2013, the EU owned the largest net wealth among the world countries, estimated to equal 27% of the 241 trillion US dollars global net wealth. Even on the scale of the individual EU states (NUTS 0 regions), however, very great differences exist in the GDP per capita indicators: they range from Luxembourg (US$107,480) and Sweden (US$59,112) to Romania (US$9,071) and Bulgaria (US$7,161) (Fig. 1). In terms of total net wealth per capita, the spread is significantly larger – from US$ 241,695 (Luxembourg) and US$232,106 (Sweden) to US$11,191 (Romania) and US$13,693 (Bulgaria) (Credit Suisse... 2013, 17).

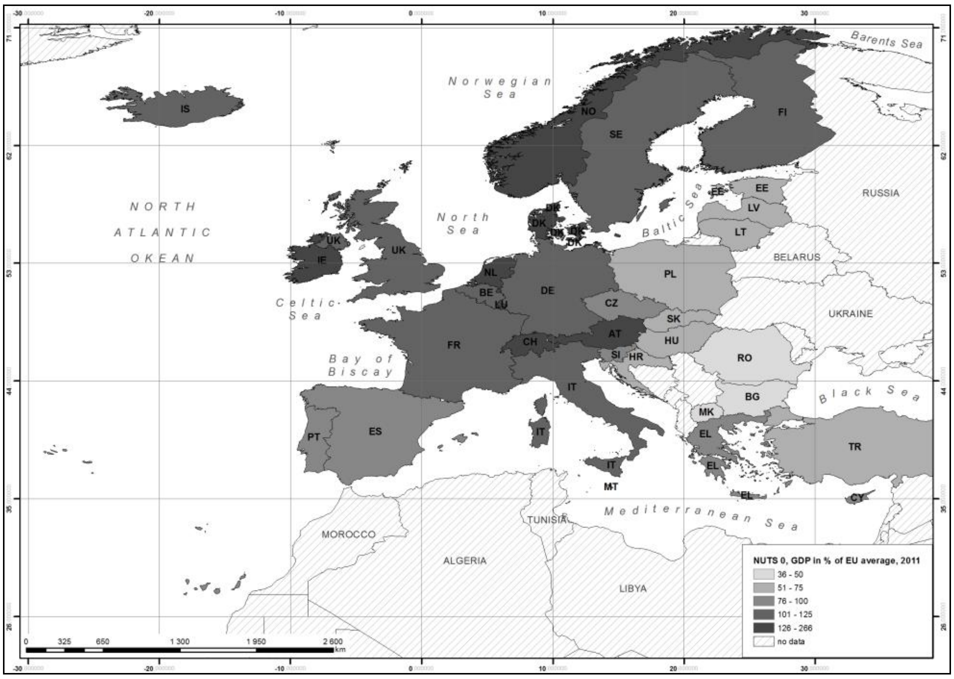

Fig. 1 – Gross domestic product (GDP) per inhabitant in purchasing power standard (PPS) by country (NUTS 0 EU regions) for 2011 (in percent of the EU–28 average, EU–28 = 100).

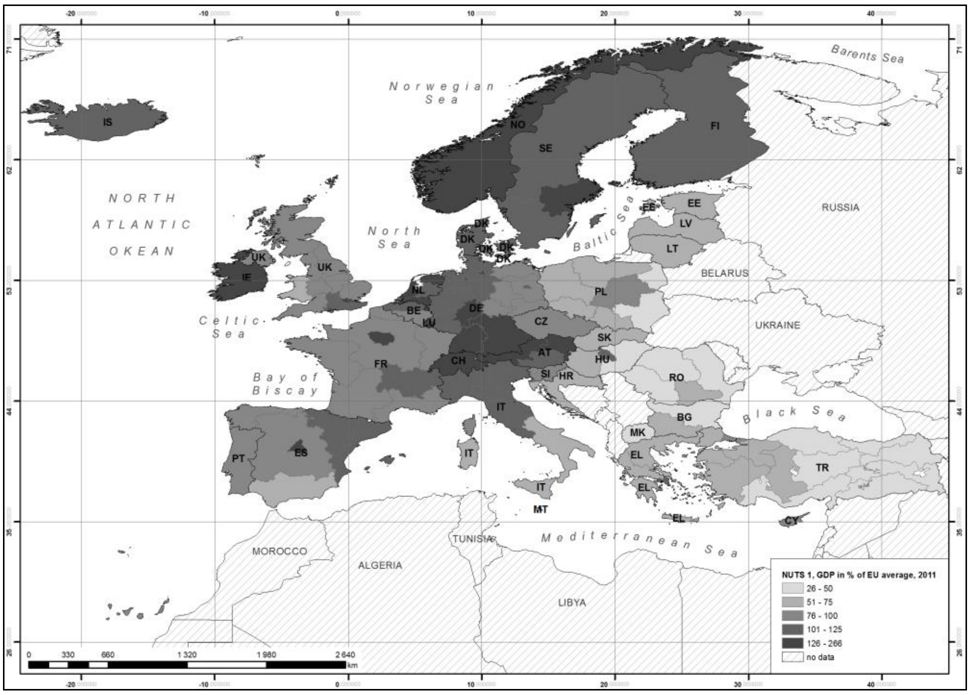

Fig. 2 – Gross domestic product (GDP) per inhabitant in purchasing power standard (PPS) by NUTS 1 regions of the EU for 2011 (in percent of the EU–28 average, EU–28 = 100).

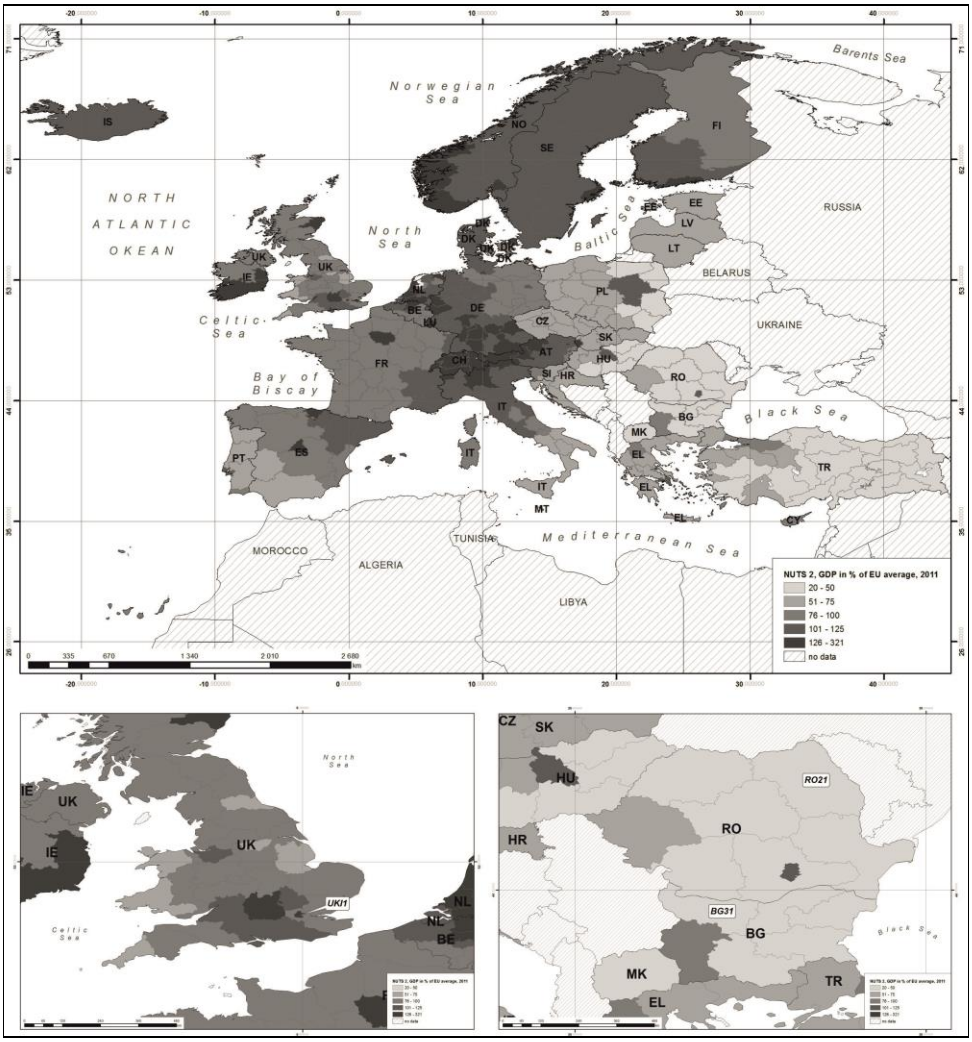

Fig. 3 – Gross domestic product (GDP) per inhabitant in purchasing power standard (PPS) by NUTS 2 regions of the EU for 2011 (in percent of the EU–28 average, EU–28 = 100).

The comparative analysis of 2011 economic data at NUTS 0 through NUTS 2 scales provides even stronger support to the observation of large disproportions in EU regional development (Figs 1 through 3). The analysis also shows that, similar to the identification of EU core, the NUTS 2 scale provides the most detailed boundaries of EU periphery. Another similarity between core and periphery is the significantly higher level of development of the capital and the highly urbanized regions. One of the reason for this phenomenon is the fact that the GDP per inhabitant levels in these regions are strongly influenced by commuter flows, which sustain much higher economic activity than that which the resident population could normally achieve (Eurostat Regional... 2014, 120). Notwithstanding the active role of demographic, economic, historical, social, and other factors, the political geographic position of the capital and highly urbanized regions invariably dominates the drivers for their formation as development “hot points”.

Thus, except for the capital regions, all NUTS 2 regions in all the eleven EU-Member States of Central and Eastern Europe (Estonia, Latvia, Lithuania, Poland, the Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Romania, and Bulgaria) fall into the category of below 75% of the EU–28 average level of GDP in PPS per inhabitant (Eurostat 2015 b). In the 2007–2013 planning period, the

EU regional development policy promoted development in the member states and regions in that category under its Convergence Objective (Regional Policy). Together with the same category regions of Southern Europe (most of Greece and Portugal, Southern Italy, and Southern Spain) and parts of Central and South-Western Britain, the Central and Eastern Europe NUTS 2 regions define the vast economic periphery of the EU, which acts as a counterpoint to the relatively "rich" EU core (Fig. 3).

The difference between the richest and poorest of the 271 EU regions at the NUTS 2 scale is larger, in comparison with the country (NUTS 0) scale. In 2011, it ranged from 29% of the EU–28 average GDP (RO21 Nord-East in Romania and BG31 Severozapaden in Bulgaria) to 321% of the average (UKI1 Inner London in the United Kingdom) (Fig. 3). At the high end, UKI1 Inner London has 80,400 PPS per inhabitant, while each of the poorest regions – BG31 Severozapaden and RO21 Nord-East – only 7 200 PPS per inhabitant (Eurostat 2015 b). The purchasing power standard per inhabitant of the richest region for the year 2011 was more than 11 times higher than that of the poorest.

A total of 76 NUTS 2 regions composed the EU periphery in 2011 (Fig. 3). A comparison of the economic and political geography information at the three NUTS scales, however, offers ample evidence that, due to peripheries' overlap, a "deep" periphery forms in the areas that are peripheral at all of the NUTS scales (Figs 1 through 3). Over a quarter (20) of the total number of EU peripheral regions record average GDP per inhabitant of less than 50% of the EU–28 average (Eurostat Regional... 2014, 122). Moreover, all of the deep periphery regions are concentrated in only four countries of Central and Eastern Europe. In addition to Hungary and Poland, particularly notable for the majority of their populations living in such conditions, are Bulgaria and Romania with over 75% of their NUTS 2 regions – the basic regions for application of regional policies – literary "falling" into that category. This special "deeper" part of the EU periphery deserves the explicit attention of the EU-level regional development decision-makers.

4. EU'S "DEEP" PERIPHERY: THE CASE-STUDY OF BULGARIA

The main task of this section is to further investigate the formation of "deep" periphery in the regions of "peripheries' overlap". For the purpose of further testing this paradigm, first, the same methods – GIS-aided mapping and comparative scale analysis – are applied at the lower – NUTS 3 and LAU 1 – territorial levels. Second, additional aspects of the political peripheries (EU's external border-areas) and a physically challenging type of periphery (mountain areas) are added as objects of the analysis. Reasons of volume and space limit this level of the investigation to the case-study of Bulgaria. The selection is based on the fact that, with the exception of its state capital region, this EU Member State has, for the seven years since its accession, invariably partaken in EU's "deep" periphery.

A/ Economic and Political Peripheries

Between 2007 and 2011, Bulgaria's economic performance had consistently placed the country (NUTS 0 scale) at the bottom of the group of EU Member States in terms of purchasing power standard per inhabitant (in 2011 – 47 percent of the average EU–28 GDP). Both NUTS 1 regions of Bulgaria also belong to the periphery. In 2011, for example, they produced less than 60% of EU's average GDP (PPS) (Fig. 4). Furthermore, the regional imbalance is very significant: the region that contains the state capital produced 1.7 times larger GDP per inhabitant in current market prices than the remaining region (BG4 Yugozapadna i yuzhna tsentralna – 6,700 euro versus BG3 Severna i yugoiztochna – 3,900 euro] (Eurostat 2015 b). At that scale, the capital region (BG4 Yugozapadna i yuzhna tsentralna) is a part of EU's periphery, while the other region, belongs to the "deep" periphery category of less than 50% of the average EU–28 GDP (Fig. 4).

At the lower NUTS 2 scale, the situation is very similar: all Bulgarian regions, except for the one that contains the capital (BG41 Yugozapaden -78%), rank significantly lower than even the deep periphery threshold – below 38% of the EU–28 average GDP (PPS). The regional imbalances substantially increase at that territorial level (Fig. 5). Compared to the "average" EU inhabitant, a person from Bulgaria's poorest NUTS 2 region (BG31 Severozapaden) had, in 2011, an almost eight times smaller purchasing power. The difference with the inhabitant of the Bulgarian capital is also quite significant – almost 4 times.

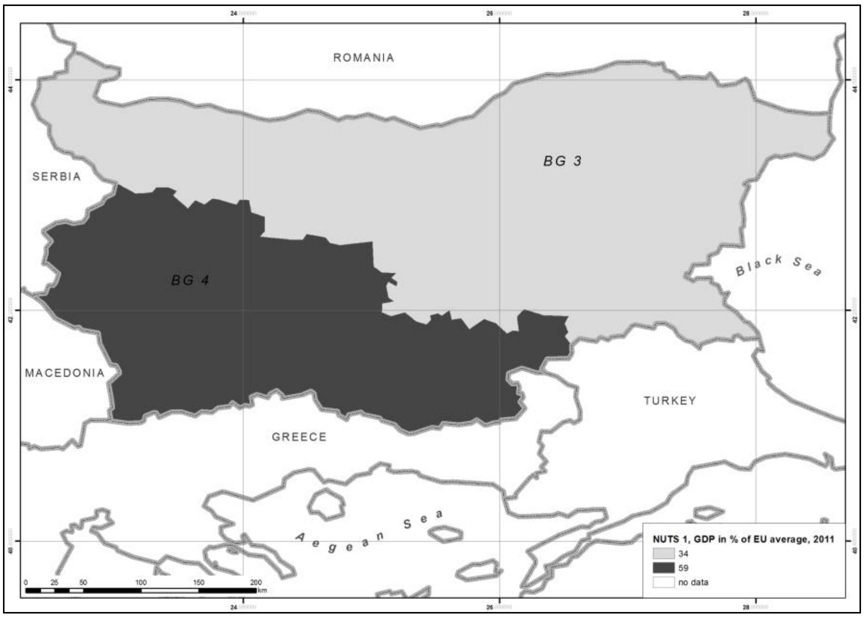

Fig. 4 – Gross domestic product (GDP) per inhabitant in purchasing power standard (PPS) by NUTS 1 regions of Bulgaria for 2011 (in percent of the EU–28 average, EU–28 = 100).

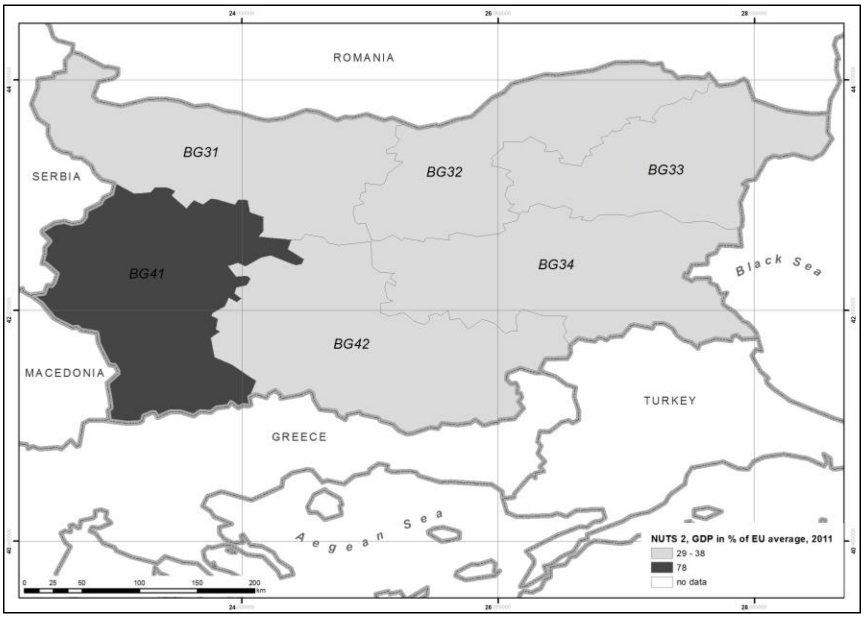

Fig. 5 – Gross domestic product (GDP) per inhabitant in purchasing power standard (PPS) by NUTS 2 regions of Bulgaria for 2011 (in percent of the EU–28 average, EU–28 = 100).

At the NUTS 3 level, the regional purchasing power discrepancy between the state capital and all the other regions in Bulgaria becomes dramatic. The capital region – BG411 Sofia City – was at the very top of the economic pyramid with GDP (PPS) per inhabitant in 2011 more than twice larger than the next region – BG412 Sofia Region – which is, in fact, its own hinterland (106% versus 52% of the EU–28 average GDP per inhabitant in PPS) (Fig. 6). No other region at that territorial level reached even 50% of EU's average per inhabitant.

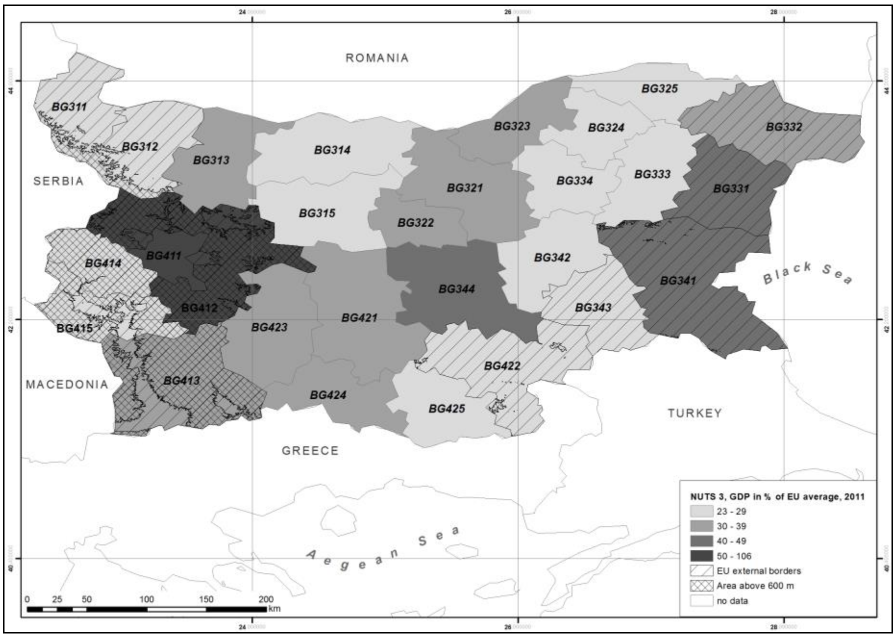

Fig. 6 – Gross domestic product (GDP), in purchasing power standard (PPS) per inhabitant in the border regions of Bulgaria that are also at the external boundaries of the EU, by NUTS 3 region areas above 600 m above sea level, 2011 (in percentage of the EU–28 average, EU–28 = 100).

The remaining NUTS 3 regions form Bulgaria's own deep periphery. The economic "powerhouses" (in PPS) at that scale of "small regions for specific diagnoses" (Eurostat 2015, a) are BG331 Varna (47% of the EU–28 average GDP per inhabitant), BG344 Stara Zagora (46%), and BG 341 Burgas (42%). The number of regions in the lower category – "30 to 39% of EU's average GDP (PPS) per inhabitant in 2011 – grows to nine: BG 421 Plovdiv and BG 313 Vratsa (38% each), BG322 Gabrovo (37%), BG323 Ruse (35%), BG332 Dobrich (31%), and BG413 Blagoevgrad, BG321 Veliko Tarnovo, BG423 Pazardzhik, BG424 Smolyan (30% each). The largest number – fourteen – of regions with very close indicator values build the bottom of Bulgaria's NUTS 3 regional economic power pyramid: BG324 Razgrad and BG315 Lovech (29% each), BG414 Pernik, BG334 Targovishte, and BG333 Shumen (28% each), BG343 Yambol (27%), BG314 Pleven and BG442 Haskovo (26% each), BG312 Montana and BG415 Kyustendil (25% each), and, at the lowest level, BG311 Vidin, BG325 Silistra, BG342 Sliven, and BG425 Kardzhali (23% each).

The location analysis of the Bulgarian NUTS 3 regions from the lowest economic category [23 to 29% of EU's average GDP (PPS) per inhabitant in 2011] also confirms the veracity of the overlap of peripheries paradigm. The majority of the economically least developed regions also constitute parts of that country's political geographic periphery, while the remaining regions in this category possess common borders with them (Fig. 6).

B/ EU External Borders Peripheries in Bulgaria

In an attempt to pinpoint and outline some of EU's "deep" periphery, i.e., the most vulnerable areas where peripheral qualities are most intensive, this research analyzes the overlap of economic and political peripheries at NUTS 3 level in the Bulgarian part of EU's external borders. The premise here is that, due to their distance from both the EU and the Bulgarian core regions, the border regions are disadvantaged and more susceptible to outside, unplanned, sometimes negative, influences. Often, such regions do not contain sizeable political centers, especially such of higher rank and key significance to the core. This section focuses on EU's external borders only and the case-study of Bulgaria offers both land and sea examples in this respect.

The Bulgarian part of EU's external border consists of two sections: A/ eastern and south-eastern, along the Black Sea and the border with Turkey, and B/ western, along the boundary with Serbia and Macedonia. Five NUTS 3 regions make up the eastern and south-eastern section of EU's periphery in Bulgaria, while the western section comprises six regions of this scale. Generally, the regions with access to the sea have a relatively higher purchasing power standard per inhabitant (30 to 49% of the EU–28 average GDP per inhabitant) than the landlocked western and southern regions (23 to 27%) (Fig. 6). Next to the capital regions (BG412 City of Sofia and BG412 Sofia Region), the Black Sea proves to be the single most important geographic factor for Bulgaria's economic development, more salient even than the size of the urban population factor, for example. The opportunities offered by the coastline, in terms of transportation, tourism and other sea resources-related activities, as well as the location of two NUTS 3 regional centers (BG331 Varna and BG341 Burgas), significantly augment the comparative political and economic position of the easternmost part of EU's periphery. As a result, while the three regions with sea access in the Bulgarian section (BG331 Varna, BG341 Burgas and BG322 Dobrich) still fall into the EU "deep" periphery category at this time, and their EU external border location is politically sensitive, they do not belong to the least-developed periphery.

The two southern regions, situated along the border with Turkey (BG343 Yambol and BG422 Haskovo), and the regions along the western Bulgarian section of EU's border exhibit the highest regional development needs at the NUTS 3 scale in the country. In 2011, the landlocked regions along the border with Turkey and the vast majority of the western EU border regions (BG311 Vidin, BG312 Montana, BG415 Kyustendil, BG414 Pernik, and BG413 Blagoevgrad) had the lowest purchasing power standard per inhabitant in the EU (23 to 30%) and constituted the best testimony of the deepest periphery (at the NUTS 3 scale), at the EU external borders (Fig. 6). Even the relative transport geography proximity of the Istanbul Megalopolis to the two southern regions has not proved to be a notable beneficial factor so far. The quite logical exception from this group of regions is the region surrounding the state capital. In terms of purchasing power standard per inhabitant in percent of the average EU–28 GDP, BG412 Sofia Region is just above the arbitrary 50% of the average EU–28 GDP deep periphery threshold. Additional and more detailed investigation should be carried out at the lower (LAU 1 and LAU 2) local scales that should include areas in Serbia and Macedonia in order to better understand the extent of the capital city's influence in the direction of the nearest state border.

While this investigation goal is to identify the most urgent regional development priority areas, it is important to note that the comparative analysis accurately exemplifies that Bulgaria's "deep" periphery at NUTS 3 scale is not located only in the proximity of borders. Its presence in other parts of the country demonstrates that neither the influence of borders in general, nor even the external EU border necessarily feature as sole determining factors in that respect. Naturally, real life situations depend on the unique and dynamic mix of factors, which is why regular monitoring at all territorial levels is necessary to secure an accurate understanding of the real state of affairs at a particular moment in time.

C/ Physical Geography (Mountain) Peripheries

Physical geographic types of periphery, and particularly mountainous areas, also plays a role in the formation of the deep periphery along the Bulgarian sections of the external EU borders at the NUTS 3 scale. To further understand the overall structure of the deep periphery, as well as to identify and describe its elements, specific to Bulgaria, this section first adds the mountainous periphery to the GIS-aided comparative analysis of the overlap of economic and political peripheries. Second, for the above reasons, this section also includes the local scale (LAU 1), which will make possible a more detailed definition of the deep periphery areas.

In their discussion of the regulatory framework of mountain areas development in Bulgaria, Koulov *et al.* (2015) point out the absence of a universally accepted definition of mountain, the differences in the world and Bulgarian scientific opinions on the height of the lowest contour of the mountain hypsometric belt, as well as the additional criteria to be used for mountain definition purposes. Since most regional development documents and many scientists in this country accept the 600 m above sea level elevation threshold, this investigation is also using it for its purposes.

The results of the GIS-supported mapping analysis show that almost all of the eastern/south-eastern section of EU's external border periphery in Bulgaria is situated below the 600 m contour line. Very small sized mountain areas – under 2% of the region's territory (National Statistical Institute) – are identified in the BG341 Burgas and BG422 Haskovo NUTS 3 regions, which necessitates taking the investigation to the local (LAU 1) scale to establish the real relevance of the respective mountain areas for the purposes of this study (Fig. 6). This stipulation is of even greater importance as far as the western section of EU's external border is concerned, albeit for different reasons. In this border section, mountainous areas largely prevail (77 to 100% of their territory is above 600 m above the sea) (National Statistical Institute) in four of the six NUTS 3 regions (BG413 Blagoevgrad, BG415 Kyustendil, BG412 Sofia Region, and BG414 Pernik) (Fig. 6). In order to accurately identify and outline only the "lowest" level periphery with highest regional development needs, the study focuses only on the mountainous local (LAU 1) level territorial units, which possess border sections that coincide with the state and EU external borders.

The shape of the region that surrounds the capital (BG411 Sofia City) is another reason that supports local level research. Mountain areas in this region extend so far away from the state border line that many local units cannot really qualify as a bona fide border periphery (Fig. 6). The proximity of the capital city – the largest political and economic urban area in Bulgaria – also adds indisputable evidence in favour of the need to take such studies to the local scale. In the case of the mountain areas of the much smaller-sized (11 to 15% of the total area, National Statistical Institute) northwestern regions (BG311 Vidin and BG312 Montana), the local scale of analysis allows also the evaluation of the economic impact of their location in respect to EU's external border.

The GIS-aided comparative scale analysis identifies 20 LAU 1 regions that are located at the EU external border and contain areas higher than 600 m above the sea level. Sixteen of them (VID25 Makresh, VID01 Belogradchik, VID37 Chuprene, MON36 Chiprovtsi, MON14 Georgi Damyanovo, SFO09 Godech, SFO16 Dragoman, PER51 Tran, KNL50 Treklyano, KNL29 Kyustendil, KNL31 Nevestino, BLG03 Blagoevgrad, BLG44 Simitli, BLG28 Kresna, BLG49 Strumyani, and BLG33 Petrich) are situated along the border's western section, while four (BGS12 Malko Tarnovo, BGS06 Sredets, HKV32 Topolovgrad, and HKV28 Svilengrad) – along its south-eastern part (Fig. 7).

The south-eastern regions will not be classified as mountainous for regional development purposes, since a really small share of their territory (less than 3%) (National Statistical Institute) is located at over 600 m above sea level. As far as most of the regions along the western EU external border section are concerned, namely VID37 Chuprene, MON36 Chiprovtsi, MON14 Georgi Damyanovo, SFO09 Godech, SFO16 Dragoman, PER51 Tran, KNL50 Treklyano, KNL29 Kyustendil, KNL31 Nevestino, BLG03 Blagoevgrad, BLG44 Simitli, BLG28 Kresna, BLG49 Strumyani, and

BLG33 Petrich, at least 40% of their territory is situated over the 600 m above sea level threshold (National Statistical Institute) (Fig. 7). Two regions along that section – VID01 Belogradchik, VID25 Makresh – possess shares of the area with mountainous characteristics of 32% and 12% respectively, but that situation still limits access to some of their resources and increases the costs of their utilization.

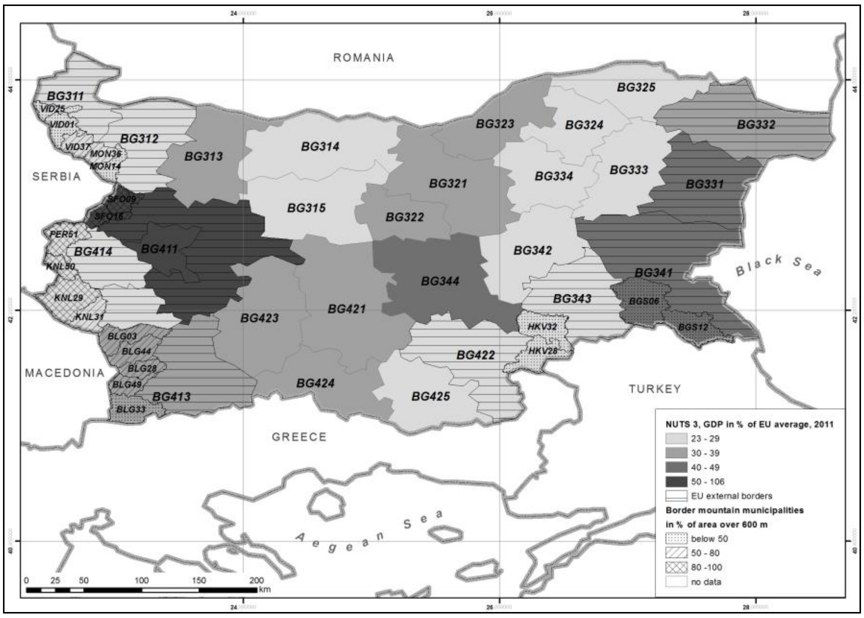

Fig. 7 – Gross domestic product (GDP), in purchasing power standard (PPS) per inhabitant in the border regions of Bulgaria that are also at the external boundaries of the EU, by NUTS 3 and LAU 1 mountain regions, 2011 (in percentage of the EU–28 average, EU–28 = 100).

The analysis results of the characteristics and structure of the peripheries’ overlap areas along the western Bulgarian section of EU’s external border identifies sixteen municipalities which are parts of EU’s “deepest” periphery, in terms of their location, altitude, and level of economic development. Taking this analysis even further, to the LAU 2 territorial level, as well as widening its geographic scope to the rest of EU’s deep periphery (e.g., Romania, Hungary, and Poland), would provide even better opportunities to assess the efficiency of the “peripheries’ overlap” paradigm to support research, as well as EU and national regional development planning and decision-making. In the case of Bulgaria, the GIS-aided comparative analysis of different periphery aspects and scales proved its ability to identify and delineate deep periphery areas – regions that are in greatest need of development assistance. This approach enables better territorial targeting of development policy measures and is, therefore, of significant value to the practice of regional planning.

5. CONCLUSION

This study draws attention to the periphery of the European Union, which, during the 2007–2013 period, EU regional development policy targeted for development promotion under its Convergence Objective. This policy addressed all Member States and regions with purchasing power standard below 75% of the EU–28 average level of GDP per inhabitant on an equal basis, while the purchasing power standard in some of them figured below 50% in 2011. This investigation supports the proposition that “deep” peripheries, i.e., areas where peripheral qualities are most intensive, form in the areas where multiple peripheries of a different nature and scale overlap. Their identification should improve priority setting in EU regional policy planning and decision-making.

In view of the above, the investigation has identified the location and outlined the territorial scope of the contemporary EU core, as well as its peripheries. It concludes that EU's economic core has expanded in the last 25 years mainly to the northeast, while the Southeast and East European Member States contain the most sizeable parts of EU's deep periphery (20 NUTS 2 regions). Most of these states and regions are located along EU's politically most sensitive external borders.

Altitude, border location and other physical and human geography factors foster peripheralization of land areas. GIS-aided mapping and comparative scale analysis of economic, political and physical geography data across five scales (NUTS 0 through LAU 1) have proven to be efficient methods for the identification of deep periphery areas, which deserve the explicit attention of EU-level regional development decision-makers. The location analysis of the Bulgarian NUTS 3 regions from the lowest economic category [23 to 29% of EU's average GDP (PPS) per inhabitant in 2011] has also confirmed the veracity of the peripheries' overlap paradigm.

Mountain areas make up large and increasing parts of EU's periphery, especially in South-Eastern Europe. As such, they should become priority objects of EU regional development policy. Instead of supporting separate conventions for sustainable mountain development, the EU and the respective Member States should design a Mountain Regions Framework Strategy that relates to all mountains within the European geographic space. Such a document should motivate and support Member States to join the existing regional conventions for sustainable development of mountain areas (e.g., the Alpine Convention, the Carpathian Convention), and/or form new, area specific, agreements. The results from this investigation prioritize the foundation of a Southeast European Convention on Integrated Sustainable Development of Mountain Regions, which should incorporate at least the EU Member States that currently are not parties to a mountain convention, i.e., Bulgaria, Croatia, and Greece.

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A METHODOLOGY FOR THE EVALUATION OF FUNCTIONAL URBAN AREAS IN ROMANIA

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Key-words: accessibility, polycentricity, functional urban areas, metropolitan areas, GIS.

Abstract. One of the main concern that arises when we acknowledge metropolitan areas as territorial units of analysis and policy development in European countries, is the lack of generic standards specifically assigned for their identification. This adversely affects the findings/results of the comparative research between European countries which use metropolitan areas as territorial units of analysis. The main objective of this article is to present an urban diagnosis methodology that aims to identify cities with the highest potential to become regional engines of development. Achieving this goal requires/involves an assessment of the 'area's ability' to generate and disperse urban development. This methodology is redefining functional urban areas and is based on the study of polycentric ESPON 1.1.1 and on a statistical-mathematical model for assessing the Functional Urban Areas (FUA-s), using a spatial database in ARCGIS 10.2.2. Any assertion of European metropolitan integrated areas requires a new strategy for maximizing the integrated development of large cities in Romania. Taking this into consideration, this scientific methodology aims to map the performance/efficiency FUA index.

1. INTRODUCTION

In order to achieve territorial development and make efficient use of the territorial potential, the European Union recommends a joint effort of the member states. Therefore, it defines six EU territorial priorities which can contribute to the successful implementation of the Europe 2020 project.

The main territorial priority is to promote polycentric and balanced territorial development, a key objective for achieving territorial cohesion. The most developed cities and regions in Europe cooperate as parts of a polycentric pattern, they add value and act as centres of contribution to the development of their wider regions (European Commission, 2011).

Polycentricity is considered a useful spatial planning tool to enhance competitiveness of cities, social cohesion and environmental sustainability (Davoudi, 2003). The use of the term polycentric or polynuclear urban region has increased greatly in the European urban (planning) literature and also in policy documents. Polycentricity within urban context literally refers to a city, region, or other geographical unit, with multiple centres (Musterd *et al.*, 2001). Polycentric development plays a key role both in academic debate on regional topics and in EU planning policies (Bertolini *et al.*, 2011).

Even one decade after the concept of polycentric development became popular and increasingly widespread in Europe as a normative policy stance, allegedly leading to cohesion and competitiveness, its empirical basis is still rather weak. This is partly due to a lack of conceptual clearness, which makes its measurement difficult (Meijers *et al.*, 2008).

The most important outcome of the discussion on the polycentricity-concept is the expressed need for a change in the perspective of the governance problem associated with multifunctionality. Taking polycentrism seriously means to understand governance as a process within which people develop knowledge and skills in order to participate in their own decision-making (Hanisch, 2006). Meijers and Burger (2010), for instance, have shown how different spatial structures – and in particular the monocentricity/polycentricity dimension – affect the economic performance of

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metropolitan areas. Also, Green (2007) argues that defining polycentricity in terms of both morphology and function is possible by drawing on techniques originating in social network analysis.

Another opinion (Shaw *et al.*, 2004) concludes that further ‘bottom-up’ comparative research and analysis is the key to future research on polycentricity in European spatial planning. Today, polycentrism is a common feature of European urban systems. In 2009, the report ‘An Agenda for a Reformed Cohesion Policy’ (Barca, 2009) acknowledged the role of networked polycentric regions as a way to promote balanced territorial development, as well as to overcome the disadvantages arising from big urban agglomerations.

From a governance and functional perspective, the functional urban areas are internationally considered to be basic units necessary for polycentric development. In the context of affirmation of metropolitan areas and intelligent metropolitan areas, an accurate definition of functional urban areas represents a process to maximize the integrated territorial development policies.

Any conceptualization and delimitation of functional urban areas must reflect their formation on the micro-scale and detect the smallest complete, complex, organic territorial units where the daily life of the population is organized. This is often neglected when a top-down approach is applied, leading to incomplete representations of reality that can misinform territorial policies (Sýkora *et al.*, 2009). S. Krätke (2007) sees metropolisation and globalisation as the main trends of spatial development in Europe. One of the key factors for business development in a region is the access to labor market and the size of it. The larger and closer the labour market, the better conditions for business development in the region are. Large cities and regions are in need to expand their labor market in order to grow and to maintain an increase in businesses, as well as to develop a proper infrastructure for transportation in order to carry commuters when it is needed (Krey *et al.*, 2011).

In polycentric regions, cities are well-connected (Meijers, 2008) and interrelated through co-operation flows (Cowell, 2010). Today, more and more jobs are created in the fringe areas, e.g. along motorways and in the vicinity of airports, but people prefer to live in the city centers resulting in genuine two-way travel to work flows. Thus, the core (the center) of the urban region and the fringe areas (the adjacent municipalities) have formed an increasingly interwoven and interactive functional region (L. Van der Laan, 1998). Metropolisation is one of the most dynamic processes of contemporary world, changing the existing settlement patterns and creating new relations between large cities (Jałowiecki, 2006). Metropolisation is transforming the economic structure and the spatial organisation of the cities involved. These cities are becoming increasingly specialised in high-order economic activities, which are intensively involved in skilled labour and information.

These typical ‘metropolitan functions’ relate essentially to creation, decision, and control. They include research and development, high-order producer services, financial activities, large companies’ headquarters, and educational and cultural activities (Bourdeau-Lepage, 2002). Mega-City Regions are nodes in the network of information flows and therefore important locations of the knowledge-based economy (KBE). This new spatial scale is recognized by planners and politicians as being crucial to develop competitive national economies (Goebel V. *et al.*, 2007).

Metropolitan areas have intensified their competition to attract and retain specific economic activities, investors and labour force. The Strategic Concept of Spatial Development – Romania 2025, had as main objective the conversion of the concepts of the European Union’s territorial policy and defining strategic objectives for spatial development in Romania, in accordance with the particular national territory (Urbanproiect, 2008). There are major socio-economic differences between cities and municipalities, but the substantial/relevant differences are observed between large urban centres and urban areas – small and medium – and rural areas (CONREG, 2013), and between the majority of resources and investments at regional or local level.

At a national level, polycentric development is needed in order to identify priorities and development goals. It is also necessary to develop an effective polycentric network, directly correlated with functional and strategic levels at a regional, county and local scale.

In the current context, a polycentric development strategy for small and medium cities, can develop on the opportunity to integrate the objectives, priorities and strategies at a larger and more relevant level (CRPE, 2013). Competitive metropolitan development challenges have become the subject of extensive academic discussions about governance (Dieleman F. M, 1998).

Several methodologies to identify functional urban areas or metropolitan areas have been developed at national and international level. In fact, the demarcation of a functional urban area or metropolitan area will differ notably depending on the methodology used.

In this regard, we chose the functional approach which defines functional urban areas or metropolitan areas based on flows between the core area and the surrounding territories. In addition, the functional approach permits to define the extension of expanding metropolitan areas, whereas the administrative approach captures static urban forms (Boix, 2007).

2. METODOLOGY AND DATA

The methodology for the identification, evaluation and classification of functional urban areas in Romania has two distinct phases: a phase of identifying potential functional urban areas in Romania and an economic evaluation stage in evolution, using numerical methods to describe non-pooled quantitative data. The first step of the methodology is to identify the potential functional urban areas using methodology ESPON 1.1.1. (Nordregio *et al.*, 2004), spatial databases and GIS capabilities. The lack of data regarding commuter flow around large cities in Romania, requires approximation of functional urban areas with Potentially Urban Strategic Horizons (PUSH according ESPON 1.1.1.).

Therefore, car travel times from the centers of the Functional Urban Areas (FUA centroids) to each node of the road network are estimated, and based on these travel times, isochrones are determined. For the purpose of this study, 30 minutes isochrones are determined.

As long as the calculation of travel time is based on an unloaded network, i.e. no traffic flows should be taken into account, it is assumed that a 30-minute-drive-time threshold turns into 45–60 minutes in real time, which is equivalent to the average commuting time. The result of this first step of the methodology is materialized by isochrones for each FUA.

For the purpose of statistical analysis and in order to assign municipalities to the FUAs, these isochrones are then approximated to municipality boundaries. The isochrones are overlaid with the municipality boundaries, and if they overlay to a certain degree, then the municipality is considered part of the Potential Urban Strategic Horizon (PUSH) (Kloosterman *et al.*, 2001). For our analysis we considered the optimal coverage of at least 50% of the municipality territory (i.e. more than half the NUTS 5 area was overlapped).

Defining 30 minutes isochrones around urban centres is based on the formation of a continuous cost surface model, in raster format, using all the transportation nodes. The travel cost value that each cell on the surface will be assigned to, is the absolute time of travelling towards the transportation nodes or towards specific network elements. On this matter, we used the Cost Distance tool to perform the cost-weighted distance analysis. This tool is an application of GIS software ARCGIS 10.2.2. Data used: Digital Terrain Model, Road Network, Rail Network, Administrative divisions, Built-up areas, Water courses and Lakes, Raster data set that contains land use according to Corine 2006.

The Cost Surface Model (MSC) result is a map raster, where each cell value represents the total number of seconds required for displacement of a specified point (or points) from a particular cell.

The second stage of the methodology acknowledges that functional urban areas stimulate the growth of the number of inhabitants, number of employees, the total turnover and local government revenue.

Starting from this premise, we developed a spatial database, which contains dynamic statistical indicators for Population, Number of employees, Revenues and Expenses, and Turnover.

The evaluation indicators in case of potential functional urban areas are:

Population Chapter – Population Urban Areas proposed in 2004–2014, The evolution of the population during 2004–2014, The evolution of the urban core (urban centre with a polarizing role in the urban areas proposed) during 2004–2014, Assessment type of population evolution for the years studied – 2004, 2008, 2011, 2014.

Number of Employees Chapter – Total number of employees in urban areas proposed in 2013, Evolution of the number of employees during the period studied (2004–2008–2011–2013), The ratio of number of employees and size of the population of urban areas proposed for the year 2013.

Revenues and Expenses Chapter – The amount of revenue from the proposed Urban Areas – 2013, The evolution of revenues Urban Areas proposed for 2013 compared with 2012, Ratio between revenue and expenditure for the proposed Urban Areas in 2013, Ratio between revenues and population for the proposed Urban Areas in 2013.

Turnover Chapter – Turnover ratio between 2013 and 2009 Turnover, Turnover ratio 2013 to population 2013 in the proposed Functional Urban Areas, Share Turnover proposed functional urban area in total turnover in 2013.

The values for each indicator are divided in 10 classes according to the quintiles method and physical values of each indicator is replaced by the quintile class. Thus, the values of all the indicators used will be transformed into quintiles values of the classes they belong to. The assessment methodology is based on identifying a single indicator for each chapter.

For the Population Chapter, a single indicator was calculated by aggregating the 4 indicators, weighted according to the following algorithm: Population Urban Areas proposed in 2004–2014 (P1) – weighting 30%; The evolution of the population during 2004–2014 (P2) – weighting 50%; The evolution of the urban core (urban centre with a polarizing role in the urban areas proposed) during 2004–2014 (P3) – weighting 10%, Assessment type of population evolution for the years studied – 2004–2008–2011–2014(P4) – weighting 10%.

For the Number of Employees Chapter, a single indicator was calculated by aggregating the 3 indicators, weighted according to the following algorithm: Total number of employees in urban areas proposed in 2013 (S1) – weighting 40%; Evolution of the number of employees during the period studied (2004–2008–2011–2013) (S2) – weighting 30%; The ratio of number of employees and size of the population of urban areas proposed for the year 2013 (S3) – weighting 30%.

For the Revenues and Expenses Chapter, a single indicator was calculated by aggregating the 4 indicators, weighted according to the following algorithm: The amount of revenue from the proposed Urban Areas – 2013 (V1) – weighting 60%; The evolution of revenues Urban Areas proposed for 2013 compared with 2012 (V2) – weighting 5%; Ratio between revenue and expenditure for the proposed Urban Areas in 2013 (V3) – weighting 5%, Ratio between revenues and population for the proposed Urban Areas in 2013 (V4) – weighting 30%.

For the Turnover Chapter, a single indicator was calculated by aggregating the 3 indicators, weighted according to the following algorithm: Turnover ratio between 2013 and 2009 Turnover (CA1) – weighting 20%; Turnover ratio 2013 to population 2013 in the proposed Functional Urban Areas (CA2) – weighting 40%; Share Turnover proposed functional urban area in total turnover in 2013 (CA3) – weighting 40%.

3. RESULTS AND DISCUSSION

The first stage in evaluating the potentially functional urban areas in Romania is based on surveys concerning accessibility on the main communication routes (roads, railway stations, airports and ports) and on the degree of accessibility within the network of urban settlements, the network of county capitals and within the urban network with a population over 20,000 inhabitants.

These accessibility studies offer the possibility to define possible functional urban areas around the county capital and around the cities that are not part of the influence area of the county capital. The steps required to identify potentially functional urban areas demanding further analysis map are:

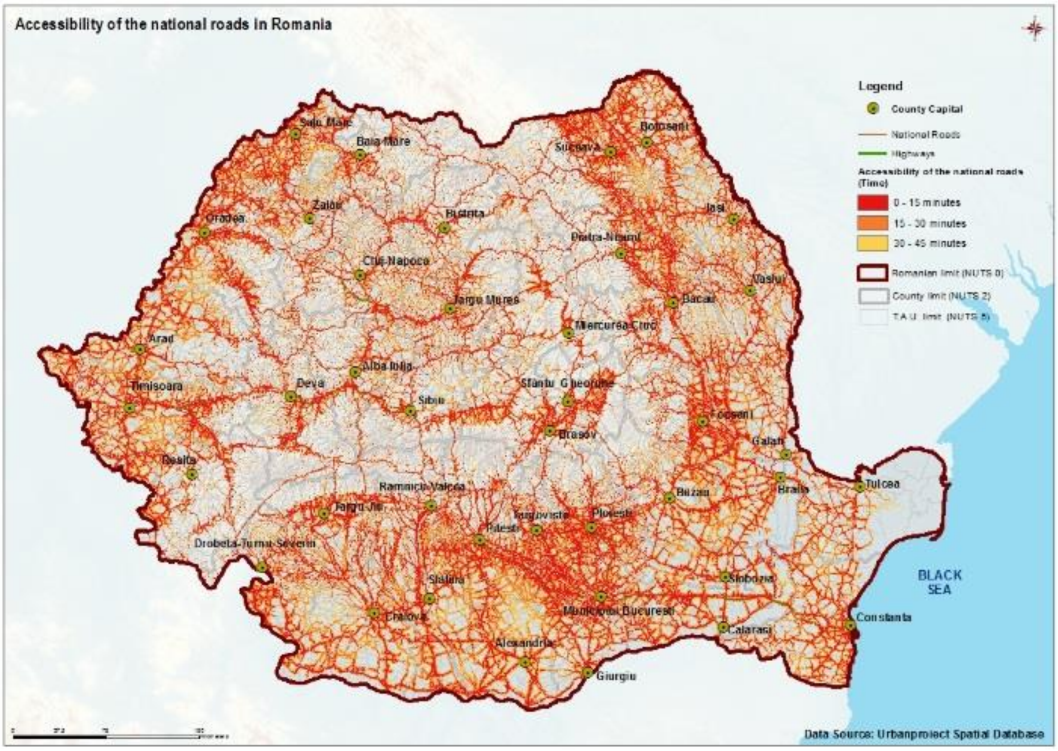

Fig. 1 – Accessibility of the national roads.

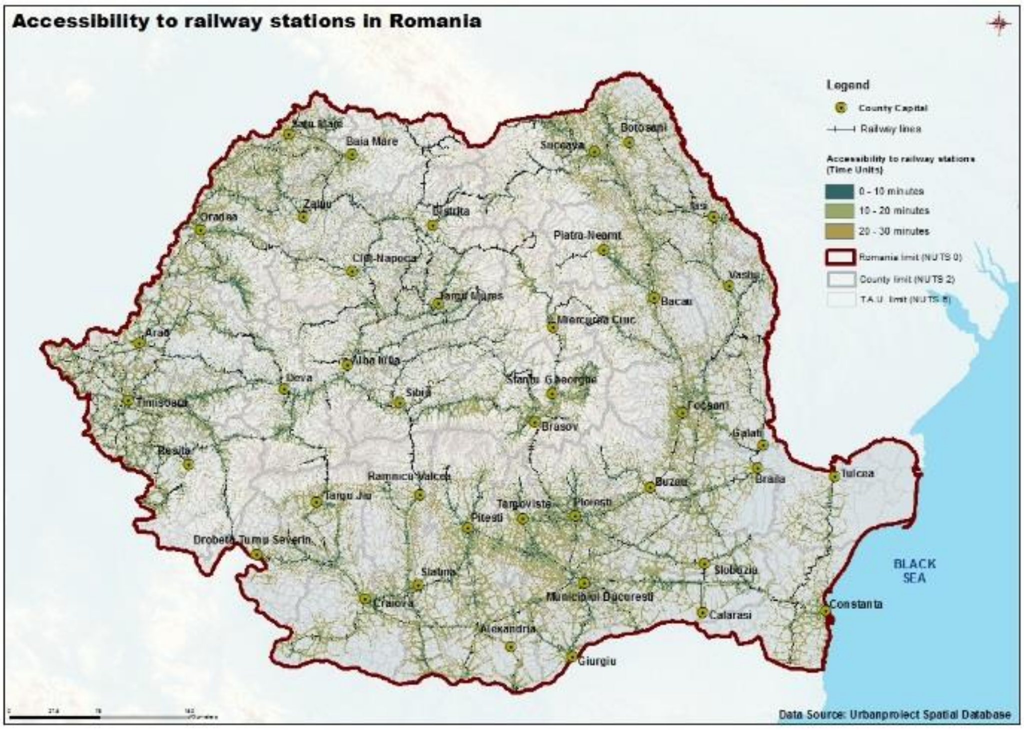

Fig. 2 – Accessibility to railway stations.

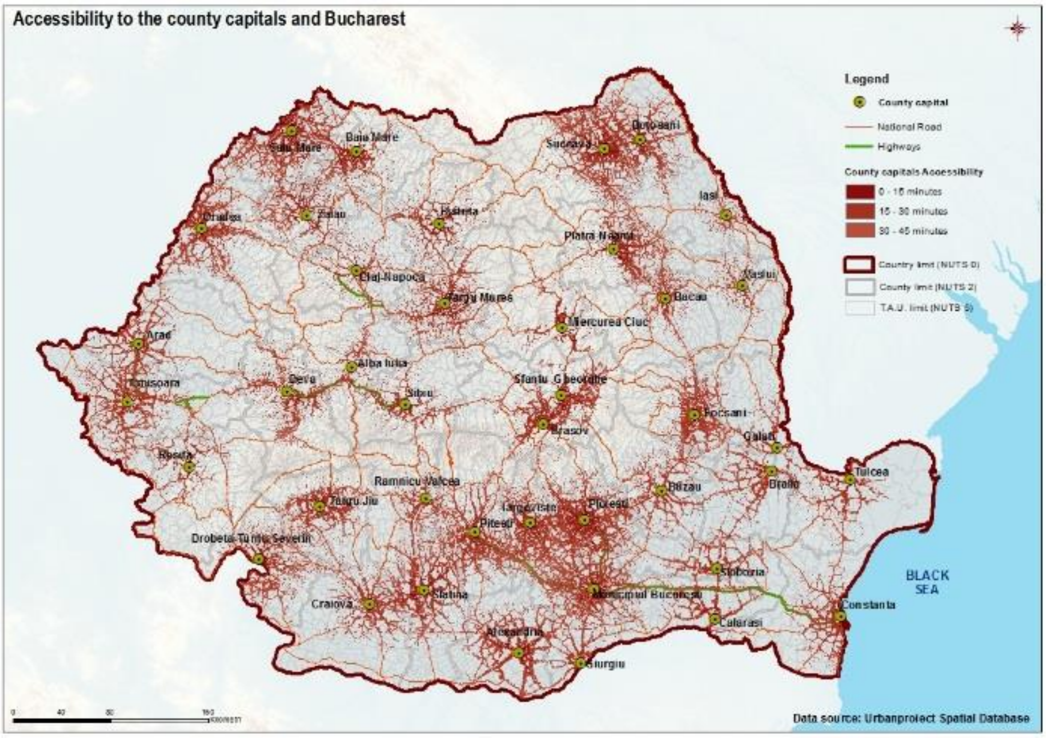

Fig. 3 – Accessibility to the county-seats and Bucharest.

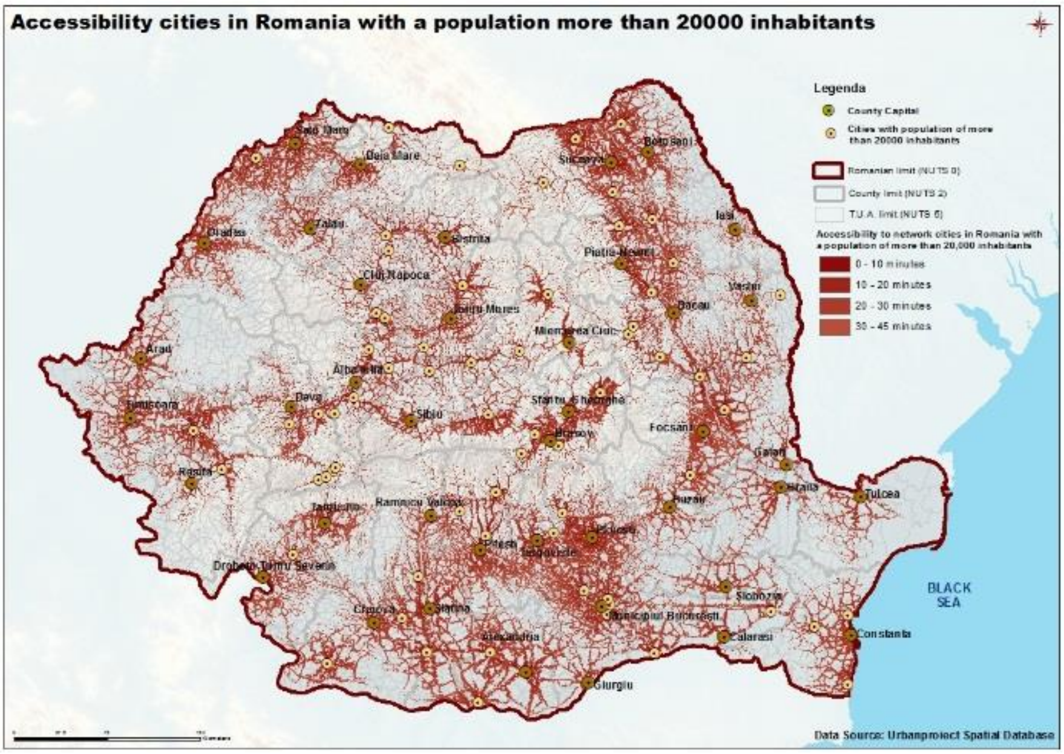

Fig. 4 – Cities accessibility with population more than 20,000.

A polycentric urban system presumes a uniform distribution of cities in the territory and not a highly polarized distribution where usually major cities are clustered only in a certain part of the studied territory. Therefore, a correct polycentric study (analysing the territorial distribution of towns, namely functional urban areas) is an important precondition. A possible approach is to divide the territory in service sectors, so that each city lies within an area which is served and can be measured in relation to the centroid of the cities studied.

For a correct evaluation we took into account the connectivity between centres, which is reflected in an increase in the annual average daily traffic.

In this study, we assume that the centers of functional urban areas are all county capitals of Romania, alongside urban centers that have a number of population exceeding 30,000 inhabitants, and do not belong to Strategic Urban Horizons of the potential county capitals.

According to the analyses conducted to evaluate potentially strategic urban horizons (PUSH) we determined the following 67 countrywide possible functional urban areas:

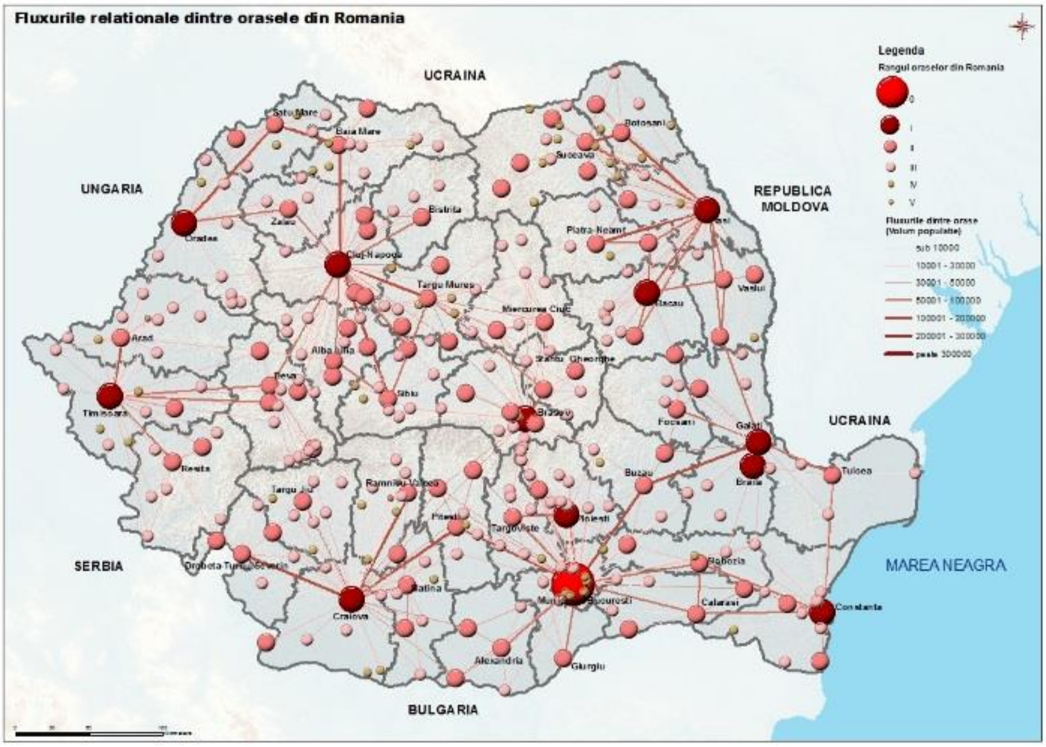

Fig. 5 – Relational flows in the regions of Romania.

The next step in Urban Areas assessment was to determine Thiessen polygons in order to characterize the spatial distribution. The territorial distribution program was made possible through ARCGIS 10.x capabilities and territorial analysis module - Spatial Analyst. We determined centroid cities that make up the network of functional urban areas and then, using the mathematical tool in Spatial Analyst module for determining a network Thiessen polygons points and a defined territory, we determined Thiessen polygons for each network of potential functional urban areas. An important element in this analysis of national polycentricity is the calculation of the polygons areas. It demonstrated that if Thiessen polygons surfaces are similar the territorial distribution of cities is closer to an ideal polycentric urban system.

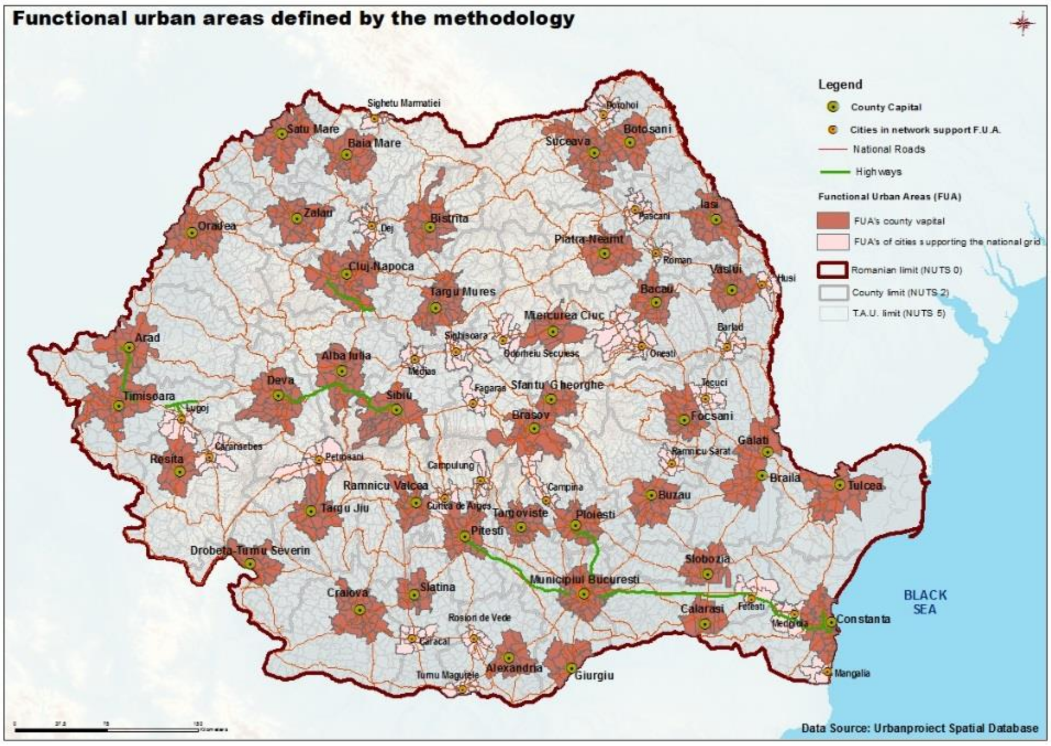

Fig. 6 – Possible functional urban areas defined by methodology.

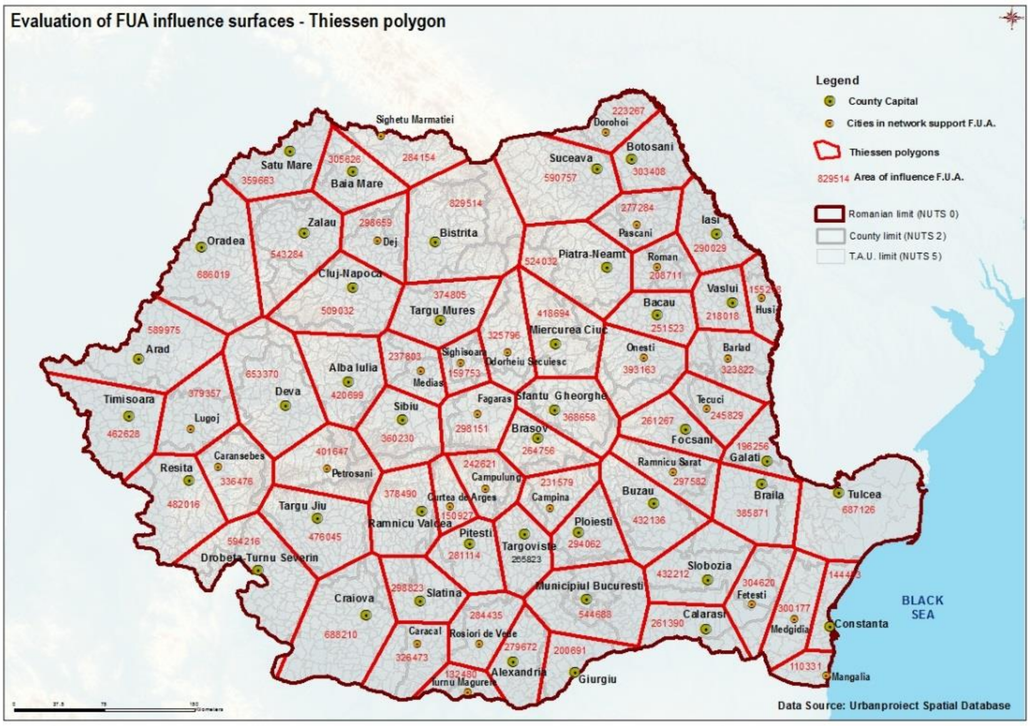

Fig. 7 – The distribution map of urban centres for functional urban areas results (Thiessen polygons).

The next step in establishing a possible polycentric urban system is to evaluate the potentially Functional Urban Areas based on the indicators already specified in the methodology part. For this purpose, a database was made, consisting of proposed territorial indicators and a study of their dynamics. The software used for these analyses was ARCGIS 10.2.2.

The final analysis was performed by determining the final index calculated by summing up the four weighted aggregate indicators as follows:

– Population Indicator– 20% weighting
– Number of employees Indicator– 30% weighting
– Revenues and expenses Indicator – 20% weighting
– Turnover Indicator – 30% weighting.

The index map of the final analysis of the potential functional urban areas in Romania is the following:

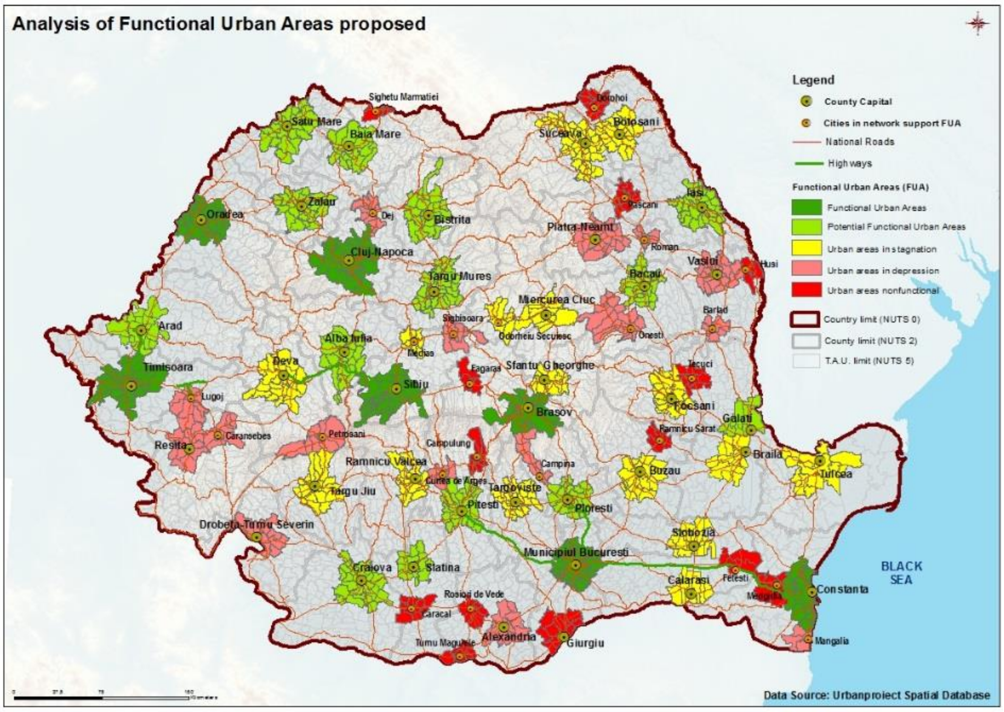

Fig. 8 – Typology of functional urban areas.

Based on the unique index obtained for all the 67 possible functional urban areas we considered five types of urban areas: Non-functional urban areas; Urban areas in depression; Urban areas in stagnation, Potentially functional urban areas; and Functional Urban Areas.

We notice that developments of communication technologies and transport infrastructure led to populating adjacent areas of the urban centres and of the adjoining communication lines. Thus, several urban areas based on urban migration in both directions emerged, actually comprising an urban centre and the surrounding settlements.

Cities like Bucharest, Cluj, Timişoara, Arad, Oradea and Ploieşti became 'metropolitan areas' by outsourcing production into new industrial platforms, within their suburban area. They also using the network infrastructure surrounding smaller cities for logistics and production.

Thus, in Figure 9 we synthesised the functional urban areas and the potentially functional urban areas.

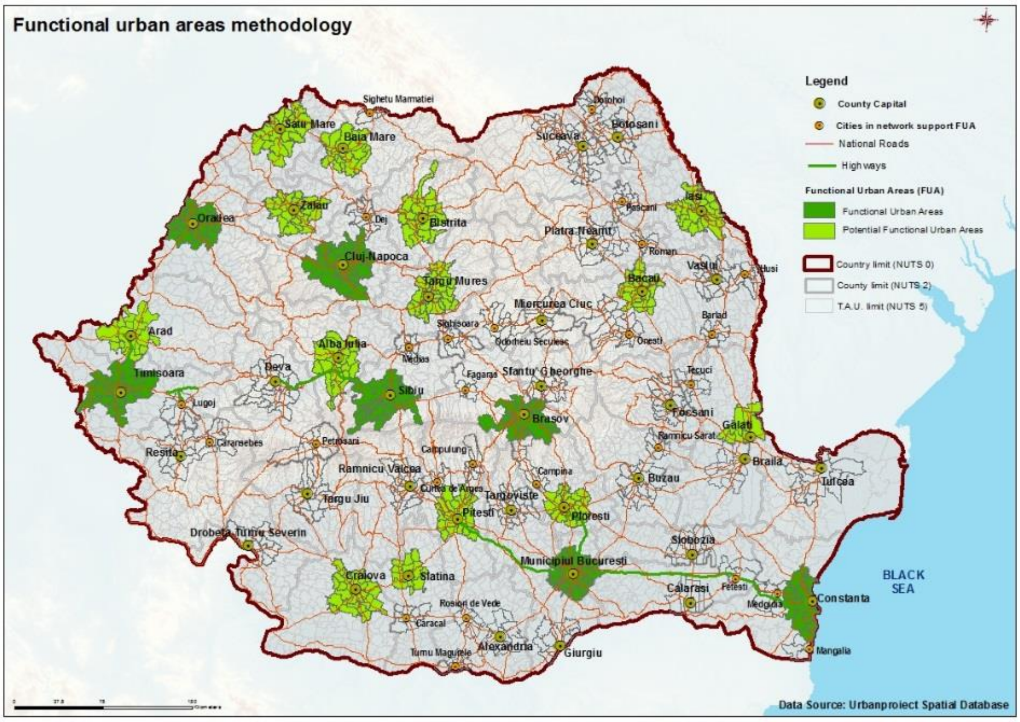

Fig. 9 – Functional Urban Areas in Romania.

4. CONCLUSIONS

Polycentricity is largely a function of connectivity, indicating the frequency and form of exchanges between urban centres, which requires connecting transport infrastructure development strategies with spatial planning strategies. Blockages occurring in Romania regarding the evaluation of polycentric development is due to the lack of data on the number of commuters and daily commute.

The proposed methodology at the Romanian level contains seven functional urban areas (2 areas in Muntenia – Bucharest, Constanţa, and five areas in Transylvania – Timişoara, Cluj-Napoca, Oradea, Sibiu and Braşov). Areas with potential to become functional urban areas are 14 in number: in Muntenia – 4 (Ploieşti, Piteşti, Craiova, Timişoara), in Moldova – 3 (Iaşi, Bacău, and Galaţi) and in Transylvania – 7 (Arad, Alba Iulia, Târgu Mureş, Bistriţa, Zalău, Satu Mare and Baia Mare). But, territorial development policies are primarily based on foreign capital inflows rather than on national, county or local capital. These foreign capital inflows support labour polarization around large cities by outsourcing production into new industrial sites, located in their suburban area.

In terms of operationality and governance, at European level, functional urban areas are considered elementary units which are compulsory for a polycentric development, therefore it is regarded as appropriate to implement the concept of functional urban areas in territorial policies, administrative procedures and legal prerequisites (Espon 1.4.3, 2007).

The assertion of European metropolitan integrated areas requires a new strategy for maximizing the integrated development of large cities in Romania. Therefore it is necessary to perform a diagnostic analysis that redefines urban functional areas of the county municipalities and to implement national strategies on achieving functional specializations and smart functional specializations. Romania needs a process of regionalization-decentralization to enable a collaboration based on integrated territorial principles. Current Intercommunity Development Associations and Local Action Groups do not qualify for the implementation of large projects.

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PASTORAL TRANSHUMANCE IN MĂRGINIMEA SIBIULUI

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Key-words: transhumance, oscillation, Mărginimea Sibiului, land use, sheep breeding, shepherding, rural space.

Abstract. This paper deals with certain aspects of a traditional activity practiced in a mountain-hilly region from southern Transylvania, called Mărginimea Sibiului. Sheep-breeding is one of the oldest activities in this area, with a significant impact on all generations, including the inhabitant of this region today. We present details of pastoral transhumance in Mărginimea Sibiului in different periods of time and nowadays, knowing that its peak was in the 18th and 19th centuries. The methodology used is based both on the analysis of a complex specialist literature and on field trips and discussions with the local authorities and the families of shepherds who currently participate in the process of transhumance. Also, in the analyses made we used statistical data obtained either from the National Institute of Statistics, or from Sibiu County Statistics Department. We established the areas of transhumance, determinant causes, restrictive factors after 1990 and the advantages of practicing transhumance.

1. INTRODUCTION

Two types of transhumance existed in Romania in historical times i.e. *beekeeping transhumance*, based on the melliferous resources and *pastoral transhumance* favoured by the natural extension of alpine and subalpine pastures and meadows, the particularities of the natural components and the traditional crafts (sheep skin processing, the furrier's trade, wool processing, etc.).

Transhumant shepherding, mentioned in historical documents as early as the 13th (1224), 14th (1383, Cristian) and 15th centuries, imposed the expansion of grasslands at the expense of forest lands, the organization of handicraft–industrial activities, professional meetings, the building of a road infrastructure (trade routes overlapping transhumance routes), the organization of huts (of the closed fold-type) and of various economic activities.

Pastoral activities in Romania highlight a reality that cannot be contested, namely, man's integration into nature, or the balance that should exist within the geosystem between the natural and the anthropic components.

Man's activities often produce environmental imbalances, which may have irreversible consequences. Therefore, knowing the limits of human intervention on the natural environment is imperative in order to preserve its particularities that ensure the existence of life.

Shepherding, as one of the oldest occupations, has a positive influence on the relationship between man and nature, stimulating partnership and not antagonism.

Mărginimea Sibiului area has a tradition in sheep-breeding, due to its geographical position in the south Transylvanian mountain-hilly area. This accounts for the vast expansion of pastures and meadows to the detriment of arable land, stimulating animal husbandry as the basic economic activity in the region.

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To conserve vegetation for grazing in the warm season, sheep flocks are moved every year between village and mountain, or between village, mountain and the lowlands. These movements take place over longer or shorter distances, depending on the size of flocks. Thus, owners with smaller flocks are annually oscillating between village and mountain, or between village, mountain and the area adjacent to the village hearth.

In the past, shepherds with large flocks practiced transhumance on longer distances, usually as far as the Romanian Plain, the Subcarpathians of Oltenia, the Dobrogea Plateau, etc. (Popp, 1932). In some cases, depending on the political and socio-economic situation, transhumant shepherds would cross the frontier into Ukraine, Russia (the Caucasus, the Crimeea), Bulgaria and Turkey. However, these were multiannual movements, and once arrived on those territories the sheep flocks would remain there for several years.

The transhumance movement in Romania was at its height in the 19th century, afterwards declining. Many causes had led to this situation e.g. the nationalization of the main means of production in the second half of the 20th century under the totalitarian communist regime and more recently, after 1990, the restitution of agricultural and forest lands replaced state property by private property.

Currently, because of difficulties in moving the flocks over private lands, transhumance is practiced on a small scale. However, in 2014 some owners from the villages of Mărginimea Sibiului (Jina, Poiana Sibiului, and Răşinari) did participate in transhumance.

Regardless of the scale of transhumance in contemporary times, its practice remains a specific phenomenon in the villages from Mărginimea Sibiului, a tradition that connects the past to the present, highlighting man's attachment to nature. Also, the conservation and development of vegetation in pastures and meadows are another favourable factor which can contribute to maintaining the ecological balance.

2. RESEARCH METHODS

This work is the result of the scientific research conducted in the rural area of Mărginimea Sibiului between July and December 2014. We used a complex methodology, based on both the study and analysis of a variety of bibliographic resources and on field trips in several representative localities such as Jina, Tilişca, Sălişte, Poiana Sibiului, Rod, Răşinari and others. A special role in this study was played by discussions with the local authorities and with families of the shepherds involved in transhumance. Statistical data were obtained from local town-halls in Mărginimea Sibiului, Sibiu Veterinary and Food Safety Department, Sibiu County Statistics Department, the National Institute of Statistics Bucharest and Sibiu General Agricultural Census.

Particular attention was paid to reviewing the Romanian geographical literature and related fields: biology, ecology, history, etc. Thus, works of regional geography, rural and economic geography were being analyzed. Of particular value are the animal husbandry studies elaborated by the Institute of Geography of the Romanian Academy in collaboration with professors from the Department of Geography, Hosey University of Japan. These works deal particularly with the breeding of sheep and the practice of transhumance in Eastern European, highlighting case-studies from Romania, Bulgaria, and Slovenia.

Likewise, a special role in this study had the works on transhumance specific to the Mediterranean countries: Spain, France, Italy, Central and Western Europe – Germany.

Finally, we would mention the variety of cartographic documents from different time-periods, matching historical documents, that helped us reconstitute the phenomenon of transhumance in the rural areas of the Romanian Carpathians.

Statistical data processing and the elaboration of thematic maps is based on the QGIS and ArcGIS software.

3. STRUCTURE, TEXTURE AND ECONOMIC FUNCTIONS OF THE RURAL SETTLEMENTS FROM MĂRGINIMEA SIBIULUI

Mărginimea Sibiului is located in the south-west of Sibiu County, at the contact between Sibiu Depression and the Cindrel Mountains. The term *Mărginimea Sibiului* has historical connotations, referring to the villages situated at the contact between mountain and the relatively flat, plain-like depression "on the outskirts" of Sibiu and an area centered on Sibiu city. The inhabitants of these villages are called *mărgineni*, being famous for their shepherding" (Irimie, Dunăre, Petrescu, 1985, p. 14).

This area of contact, called Mărginimea Sibiului includes 17 settlements (16 villages and one town), which extend between the Olt Valley to the east and the Sebeş Valley to the west, covering about 1,335 km^2. The settlements are Boiţa, Sadu, Râu Sadului, Tălmăcel, Răşinari, Poplaca, Gura Râului, Orlat, Fântânele, Sibiel, Vale, Galeş, Tilişca, Rod, Poiana Sibiului, Jina, and Sălişte, the last one having town status since 2003. Mărginimea Sibiului encompasses also territories belonging to 12 territorial-administrative units: 10 communes and 2 towns (Fig. 1).

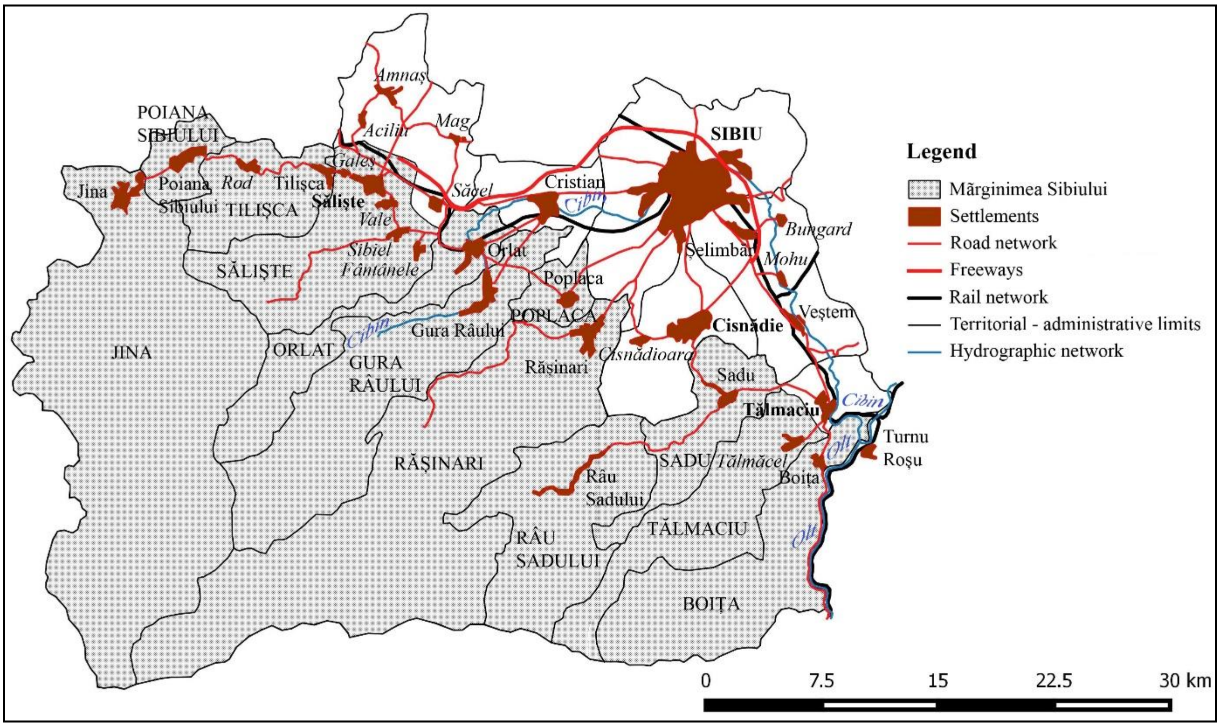

Fig. 1 – Settlements from Mărginimea Sibiului.
(Source: Processed after the Topographic Map of Romania, scale 1: 200 000).

The structure of settlements from Mărginimea Sibiului is influenced by the geographical position of this area, between a submontane depression and the Carpathian Mountains. These settlements are located on the southern outskirts of Sibiu Depression, their village hearth partially extending on the piedmont steps of the Cindrel Mountains. It is the southern alignment of the settlements in the depression area, where both the village hearths and especially the estates (lands adjacent to the hearths) rise on the northern slopes of the Cindrel Mountains, including even the Alpine area.

The geographical position of these settlements explains the name *Mărginime (outskirts)* given by geographers and researchers from other fields (historians, sociologists, ethnographers, etc.).

In general, these settlements have a compact structure specific to depression areas. Households (home and annexes) are located at a small distance from one another, showing compacting trends especially in the central area. The space between buildings is generally small, including agricultural lands used “within the village hearth.” The built area can be clearly delimited from the adjacent surfaces (estate) of agricultural use, or most often of pastoral use.

A specific feature of the villages advancing into the mountain area is their hearths are located on the piedmont step of the Cindrel Mountains. In this case we notice a compact structure in the central area, or the core of the hearth, and scattered structures in the outskirts, depending on the configuration of the relief and the hydrographic network, households being located, tentacle-like in the valleys. This is specific to the rural settlements of Jina, Poiana Sibiului, Rod, Tilişca, Sibiel, Fântânele, Gura Râului, Răşinari, Râu Sadului, and Tălmăcel.

Sălişte (town-status since 2003), is the only urban settlement in Mărginimea Sibiului, a status based mainly on demographic grounds (over 5,000 inhabitants, together with the rural settlements pertaining to it). The structure of the town observes the configuration of the rural settlements in these areas, with a compact core and scattered towards the outskirts, the hearth expanding north-westwards – south-eastwards.

In the case of both compact and scattered rural structures, the built area is well-outlined, distinct from the lands adjacent to the hearths.

Currently, the hearth of the settlement core has a tendency to compacting, while the scattered outskirts have a tendency to expanding.

The *texture* of settlements refers to the layout of buildings in the hearth in relation to the configuration of the street network. This reflects the internal order of the streets.

The oldness of settlements in Mărginimea Sibiului shows certain irregular textures, specific to villages that were not subjected to systematization and territorial planning. In this sense, the street network has a circular or radial arrangement (the streets are usually diverging from the core, or the center of the locality, towards the outskirts of the hearths). There are also newer settlements (Râu Sadului, documented in 1850) with a monolinear or bilinear texture. Râu Sadului has a monolinear texture, the hearth lying along DJ 105G (county road) and being parallel to the Sadu River. Likewise, Prislop Village, which pertains to Răşinari Commune, has a bilinear texture, being a relatively new village, documentary attested in 1954.

The *form* of settlement hearths in Mărginimea Sibiului is predominantly irregular polygonal, due to their unsystematized evolution. The largest hearths are specific to Poiana Sibiului, Sălişte, Orlat, Gura Râului, Răşinari and Sadu. The tentacle-like hearth of Jina Commune covers a large surface, due mostly to its territorial location on the highly fragmented piedmont relief. Regular forms of the rectangle, square or triangle type, are specific only to the new settlements, built according to some systematization plans.

The *geo-economic functions* specific to the settlements of Mărginimii Sibiului are centred on two types of activities: *agriculture*, focused mainly on animal husbandry owing to large pastures, meadows, and *forestry* lands; forests represent an element particular to this area.

The total agricultural land of the 12 administrative units (10 communes and 2 towns) that form Mărginimea Sibiului covers 1,334.93 km^2. The largest expansions (over 200 km^2) are specific to Sălişte Town and Jina settlement. Surfaces larger than 100 km^2 have four settlements with: Tălmaciu, Răşinari, Gura Râului and Boiţa, the smallest one are in Poplaca, Râu Sadului and Poiana Sibiului.

The land fond structure is dominated by forest land, (almost 60% of the total surface), and agricultural land (over 1/3 of the total of Mărginimea Sibiului). The other land fond categories, that is, ways of communication, buildings, waters, unproductive lands (total 4%), each category having one percent of the overall land fond.

The agricultural surface (arable lands, pastures and meadows, vineyards and orchards) covers 505 km^2, i.e. 38% of the Mărginimea Sibiului land fond. The largest agricultural areas belong to Sălişte (124 km^2 or 55% of the total area), Jina (80 km^2 or 25% of the total area) and Tălmaciu[9] (73 km^2, respectively 29% of the administrative total of this settlement). The reduced agricultural surfaces of Tălmaciu and Jina come from the forest expansion specific to the mountain zone.

The agricultural use highlights the hilly-mountain specificity of this area, with over 80% meadows and pastures and only 14% arable land of the total surface-area, which explains the pastoral function of these settlements.

In general, areas expanding on mountain steps (Jina, Orlat, Gura Râului, Răşinari, Râu Sadului, Tălmaciu, and Boiţa) have small agricultural surfaces (under 40% of the total land), compared to others that expand northwards, in depression or plateau areas (Sălişte), where agricultural land represents over 50% of the total surface of localities.

Due to the submontane relief, arable lands are not very extended, differences among the communes resulting, on the one hand, from the size of the territorial-administrative units, and from distinct fragmented relief lands, on the other. Arable lands hold the highest percentage of the agricultural surface, over 20%, in the settlements which include relatively flat surfaces located at the contact between the depression, the piedmont and the glacis, e.g.: Orlat (34%), Poplaca (32%), Sadu (26%), Gura Râului (24%), communes and Sălişte town (21%).

At the other end of the spectrum are the settlements that occupy partly the northern slopes of the Cindrel and the Lotru mountains up to the watershed, such as Râu Sadului, Poiana Sibiului, Jina and Tilişca communes, where arable land represents 4% of total agricultural land.

In the settlements that have little arable land, pastoral and forestry uses prevail.

Thus, pastures and meadows have the highest share in the Râu Sadului, Poiana Sibiului, Jina, Tilişca and Boiţa communes (over 90% of the total agricultural land), but referred to the total land fond, it is Sălişte, Poiana Sibiului and Tilişca that rank first with 40% – 60%. Usually, the largest areas are occupied by pastures, with the exception of Jina, Râu Sadului, Sadu and Tilişca, where natural meadows prevail.

Orchards and vineyards are not specific to this region, except for Sălişte which has 220 ha of orchards and 101 ha of vineyards, that is almost 3% of the total agricultural surface.

Forests sum up 77,807 ha, which represents 59.17% of the administrative-territorial total that includes Mărginimea Sibiului. Most forest land have Jina commune and Tălmaciu town, 24,032 ha and 12,836 ha, respectively (74% of the total land fond in Jina and 69% in Tălmaciu Town); between 6,000 and 8,500 ha forest land have Sălişte Town, Gura Râului, Răşinari and Boiţa communes.

Since all these settlements have the estate on the northern slopes of the Cindrel and the Lotru mountains, which explains the wealth of forest land.

Therefore, animal husbandry and forest exploitation are the basic functions of these settlements, in addition, rural tourism and agro-tourism is being practiced in Mărginimea Sibiului, as part of promoting and developing green tourism.

4. PASTORAL TRANSHUMANCE: PAST AND PRESENT

The activities connected with sheep-breeding are an ancient tradition here, the rural area of Mărginimea Sibiului being a unique territory where natural resources and environmental conditions converge.

Transhumance is a very complex process, involving the movement of flocks to the mountain in the warm season and their return to the plain in the cold season.

The term comes from Latin where *trans* means *across, from one end to another* and *humus soil, land, ground*. The term *transhumance* was used in the Mediterranean area (Spain, Italy, France), being introduced in the scientific literature by Paul Vidal de la Blache, at the end of the 19th century (Rinschede, 1988, p. 97).

In the family of Romance languages the term *transhumance* is still used today, it referring to migration and seldom to the movement of livestock.

Geography has extended the meaning of this term, it currently standing for an economic form of having sheep flocks moved to the alpine pastures (Beckinsale, 1975, pp. 68–75; Rinschede, 1988, pp. 96–108; Yasuda, 1958; Tsukihara, 1992).

According to the Explanatory Dictionary of the Romanian Language, 1998, the term *transhumance* originates from the French word *transhumance* and represents *the periodic migration of shepherds and their flocks from the plain to the mountain, or from south to north in spring, and from mountain to plain, or from north to south, in autumn, to secure the food they need.*

When these movements occur only in the perimetre of residential settlements, covering short distances, they are called oscillation shepherding. The owners who have a small number of sheep practice this type of transhumance, basically between the mountain and the village hearth, or to its adjacent area. Transhumance may also cover long distances over hundreds, sometimes even thousands of kilometres; this is big transhumance, *small* transhumance being limited to the area close to the residential neighbourhood.

Transhumant shepherding has always been connected to a stable place, being specific to sedentary populations (Panaitescu, 1969), while nomadism implies continuous change of residence, never practiced by Romanians. This clarification is welcome to avoid confusion between the term transhumance and nomadism, the latter being characteristic of migratory populations.

Historical documents record the participation of shepherds from Mărginimea Sibiului in the process of transhumance as early as the 13th century, also testified in the chronicles of the Hungarian King Bela the Fifth. Documents belonging to Voivode Mihai, the son of king Mircea cel Bătrân (the Old), state the right of the shepherds from Mărginimea Sibiului to graze on the southern slopes of the Carpathians, i.e. on the territory of Wallachia. The practice of transhumance is also confirmed in the next centuries, the peak period being 1700 – 1900, when the numer of sheep flocks moved significantly increased. *Almost every village had its area of natural pastures in the Lotru and the Cindrel mountains. Tălmăcel Village alone owned seven mountains, practicing the rotation-grazing system* (Irimie *et al.*, 1985).

Also, the distances travelled have increased beyond the country's borders, on the territories of neighbouring states: Bulgaria, Hungary, Ukraine, sometimes reaching as far as Russia, Turkey, or Croatia.

Transhumance can have multiple causes, e.g. the different quality of pastures, the large number of animals (sheep), the absence of hay-fields in the cold season, the warmer climate in the plain, hence a longer period of vegetation over the year.

As from the 20th century, transhumance began declining due to the evolution of society, but primarily to the socio-political factors. Thus, the enlargement of cultivated lands in the Bărăgan Plain and the land reform at the end of the 19^{th} century, after the War of Independence, represented restrictive elements for transhumance because of the expansion of private lands. Likewise, the so-called *customs war* between Romania and Hungary (1885–1896) made many sheep-owners turn to other activities (cultivation of trade plants, etc.).

After the end of the First World War and the formation of the National Unitary Romanian State in December 1918, there followed a period favourable for the development of transhumance, as the Romanian lands, abusively confiscated by the Saxon minority, were recovered.

Transhumance was also practiced during the communist regime, when the land was state property, and after the change of the political regime in December 1989. It is true that transhumance was less intensely practiced due mainly to the restitution of agricultural land to former owners, state property being replaced by private property.

In Mărginimea Sibiului, where animal husbandry represents the main occupation, transhumance has been practiced in all the 17 localities, the intensity of this practice varying with the period and the number of animals.

The movement of flocks in the four seasons of the year represents a very interesting process, not only of movement between village and mountain, but also of a small transhumance, in areas adjacent, or close to neighbourhood it Mărginimea Sibiului. Thus, in the warm summer season all flocks are ushered up to the mountain, to the alpine pastures and meadows beyond the timberline. In winter, the flocks come down either in the sheepfold of the owners with a small number of animals, or close to it in the so-called the hut area, where hay is stored for the cold season. In the intermediate seasons, in spring and autumn, some sheep-owners with small flocks participate in small transhumance, those with large flocks join big transhumance. In autumn, transhumance begins, ending up in spring, when the flocks return to the pastures and meadows around the settlements.

Small transhumance moves to the Hârtibaciu Plateau, Târnave Plateau or Făgăraş Depression, while *big transhumance* covers long distances from the residential place, basically to the West Plain and Hills, or to the Dobrogea Plateau and the Romanian Plain.

Shepherds with few animals do not practice transhumance, oscillating only between the mountain and the valley (residential village). Oscillation is simple, when the movement takes place only on the mountain-village distance, or double, when in transitional seasons (spring and autumn), the flocks arrive on the meadows and pastures at some distance from the village, ascending or descending afterwards (depending on season), along the mountain-valley itinerary.

Among the settlements of Mărginimea Sibiului, – Poiana Sibiului and Jina are representative for the type of shepherding. Poiana Sibiului is a typical pastoral village, with a small estate, which implies a complex system of moving the flocks. Owners with few sheep practice shepherding near the village hearth even in the warm season. In autumn, they move to the neighbouring areas of the Apold Corridor and the Secaşe Plateau, coming back in spring near the village. As already mentioned, this form of transhumance is called small transhumance.

People who own large flocks practice oscillation shepherding between the village, the mountain and the adjacent areas. There are also shepherds going on big transhumance, moving to Banat, Crişana or the Bărăgan Plain in the cold season.

Land restitution poses difficulties in practicing transhumance over long distances and in this situation some owners moved their flocks permanently to lowland regions with a milder climate (Banat), buying agricultural land there, but keeping their residence at Poiana Sibiului.

Jina Village has a shepherding system as complex, due both to its geographical position (inside the mountain-hilly area) and the large number of animals. The movement of flocks in this area is very interesting. In winter, smaller flocks stay in the village sheepfold, or in the huts of the adjacent area (the Apold Corridor and the Secaşe Plateau), larger flocks being sheltered at longer distances, in Banat, Crişana or the Bărăgan Plain. In spring, they practice transhumance around the village, first on the *lower boundary,* where there are no huts, then they go to the *upper boundary*, in the area of huts and natural meadows. In summer, all the flocks move on the northern slopes of the Cindrel Mountains, to the alpine pastures, coming down to the village in autumn, using first the pastures from the upper boundary and then those from the lower boundary (Voicu-Vedea, 1998, p. 138).

In the second half of the 20th century and the first decade of the 21st century, the sheep livestock of Mărginimea Sibiului registered fluctuating values.

With the exception of 1990, in all reference years the number of sheep exceded 100,000 heads, highest numbers being registered in 2010 (almost 190,000 heads), with an increasing trend over the last 25 years. The revival of the shepherding tradition in Mărginimea Sibiului area was mainly the result of having state property replaced by private property after the political change of 1989, and the support given by the government to this activity; in recent years, shepherding has received financial support based on certain development projects for the Romanian rural area.

Overall, the number of sheep has generally decreased in the second half of the 20th century, lowest value being recorded in 1990 (under 90,000), but in the following two decades, their number would double. It is an encouraging phenomenon, which shows the continuity of a tradition specific to the mountain–hilly area of southern Transylvania and, at the same time, the capitalization of the agricultural potential, which will contribute to the sustainable economic development of this area.

Outstanding settlements in terms of sheep number are: Poiana Sibiului, Jina, Răşinari, Tilişca communes and Sălişte Towns. In 2010, they totalled 158,240 sheep, that is 84% of all sheep registered in Mărginimea Sibiului. Only two communes, Jina and Poiana Sibiului, held 106,762 heads, or 56% of the total number of sheep in Mărginimea Sibiului.

Lower values (under 10,000 heads) registered the other settlements, and more than 4,500 – 7,000 sheep had those from Gura Râului, Orlat, Râu Sadului, Sadu and Tălmaciu.

These settlements own 14% of the sheep total in Mărginimea Sibiului. Sadu and Tălmaciu stand out with 12,503 sheep (46%), which belonging to the above group of five localities, or 7% of the total sheep livestock of Mărginimea Sibiului.

The communes of Boiţa and Poplaca have the lowest record, nearly 2% of the total number of sheep existing in the villages of Mărginimea Sibiului. Poplaca had only 846 sheep in 2010, the commune possessing the smallest pasture and meadow areas (under 900 ha).

It is estimated that the number of sheep is directly proportional to the size of the pastoral area, so that the number of animals depends on the pasture and meadow area of respective communes.

Looking at the village statistics, one finds a numerical increase of sheep in most settlements over 1941 – 1985, except for three communes – Poiana Sibiului, Tălmaciu and Tilişca; a steep decrease is recorded, head at Poiana Sibiului, which lost half of the flocks, from ca. 80,000 to ca. 35,000 heads.

This situation was determined by the nationalization of the main means of production and by the practice of socialist farming. However, in the other settlements, state ownership over the land led to livestock increases, yet not beyond 30,000 heads, except for Jina, where from 4,500 sheep, they reported over 26,000 in 1985; the other settlements of Mărginimea Sibiului had a modest record, only at Răşinari, Sălişte and Tilişca the situation looked better (more than 14,500 heads).

During the last period of communism, livestock continued to decrease in almost all the villages from Mărginimea Sibiului. It was again, Poiana Sibiului that registered biggest decreases, from 35,000, little more than 11,000 sheep were left. These figures show the difficulties of the Agricultural Production Cooperatives in the monitoring and management of livestock in the conditions of the central-based economy and state ownership over the land.

After 1990, when the state-based economy was replaced by private property, livestock increased in almost all the settlements. Once again the two villages – Poiana Sibiului and Jina, where sheep-breeding is a traditional occupation, are outstanding with 2.5 time increases at Jina and 5.4 times at Poiana Sibiului. Highest increases had Tilişca Village, by 7.7 time more sheep in 2010 than in 1990. The two driving forces that stimulated animal breeding in Mărginimea Sibiului area were the replacement of state property by private property and the implementation of government projects for the development of this sector.

Transhumance routes covered various distances, depending on the size of flocks. Shepherds with smaller flocks practiced the so-called *small transhumance* on small distances, in the adjacent area of the residential neighbourhood. Winter was spent mostly in the localities of Sibiu County, or of the neighbouring counties of Mureş, Braşov and Alba, especially on some Hârtibaciu Plateau villages: Nocrich, Cornăţel, Nucet, Marpod, and Roşia; Sibiu Depression: Şura Mare, Mică, and Cristian; Apold Corridor: Apoldu de Sus, Apoldu de Jos, and Câlnic; Târnave Plateau: Micăsasa, Sânmartin, Zagăr, Aţel, Viişoara, etc.

Big transhumance was practiced by shepherds with large sheep flocks over long distances from the residential settlements (hundreds or even thousands of kilometres) to the Romanian Plain: the Oltenia Plain, the Danube Floodplain and the Brăila Plain, the Dobrogea Plateau, the West Plain and Hills. The Cindrel and the Lotrului mountains were crossed through passes and gorges (Turnu Roşu–

Cozia Gorge, or Loviştei, Arefu, Horezu, Novaci, Olteţ lands, etc.). From the Subcarpathian area shepherds would follow along the roads situated in the main valleys (Fig. 2).

The main routes followed by shepherds practicing big transhumance across Romania went as follows:

– west and south-westwards to Crişana and Banat: Mărginimea Sibiului – Apold Corridor – Sebeş Valley – Mureş Corridor – Deva – Ilia – through Lipova, Arad or Timişoara, or through Margina – Lugoj towards the same destinations; those who went to Crişana, travelled from Deva to Brad and farther on to Oradea;

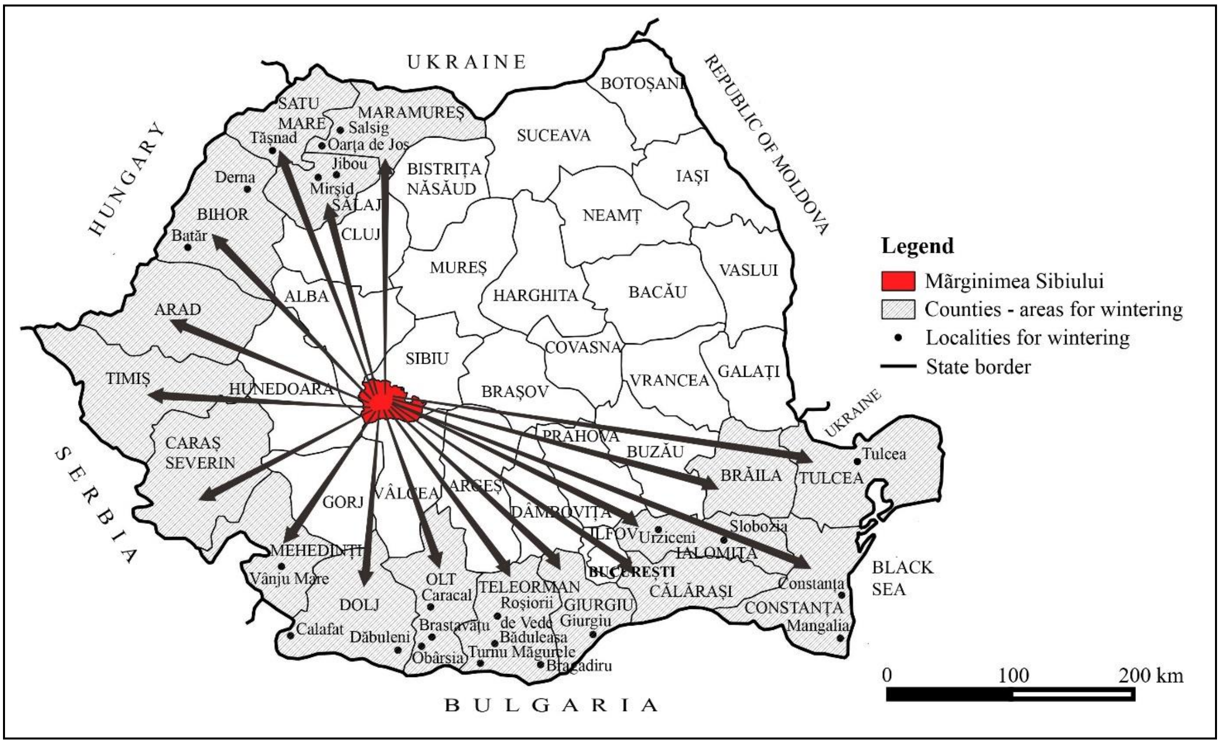

Fig. 2 – Transhumant movements in the country.

– north-westwards the itinerary went through Miercurea Sibiului – Blaj via Secaşe Plateau – Ocna Mureş – Câmpia Turzii – Turda – Cluj-Napoca – Oradea or Dej – Jibou – Baia Mare – Satu Mare;

– south and south-eastwards they followed the Hârtibaciu Valley – Rupea – Braşov, farther on to the Prahova Valley towards Ploieşti – Urziceni – Slobozia and crossing the Danube at Giurgeni – Vadu Oii. Another route followed the Olt Valley through the Făgăraş Depression, farther on through Braşov Depression and Bratocea Pass, arriving either in Buzău County, or in Brăila County. From this point, some shepherds continued the way to Dobrogea, either in the north atTulcea, or in the south at Constanţa. Another route followed the Olt River towards Râmnicu Vâlcea – Drăgăşani – Roşiorii de Vede – Zimnicea or Turnu Măgurele – Suhaia.

In general, moving to wintering places began in the second half of September and lasted minimum 30 days, depending on the distance.

Until 1878, many shepherds crossed the southern borders of Wallachia and led their flocks for wintering in Bulgaria and Turkey.

However, after the War of Independence (1877–1878), the main directions would be east- wards, on the territory of Basarabia, up to the Crimean Peninsula, at distances of 700–900 km and to the

Caucaus area, at about 1,200 km. The first inhabitants who led their flocks towards the east, beyond Romania's borders, were the shepherds of Rod Village. First, they entered the territory of Ukraine, after which some of them ended up in the Crimean Peninsula and the Caucasus area, where they would marry and become integrated with the local population. There were groups of shepherds from Mărginime who moved to the remote region of Astrakhan, attracted by the famous Karakul breed. After the establishment of communism in 1917, they would also fully integrate with the local population, settling permanently there (Irimie, Dunăre, Petrescu, p. 204, 1985) (Fig. 3).

In this case, the annual movement of flocks was impossible, so that the flocks stayed in those areas for longer periods of time. After 1990, the process of transhumance declined as state property was replaced with private property, a phenomenon that hindered the movements. However, in the settlements of Poiana Sibiului and Jina, which have a small area, transhumance is practiced in the transitional seasons, even today.

Fig. 3 – Transhumant movements abroad in the 19th and early 20th centuries.

Even if the annual movements face a series of difficulties, there are many sheep-owners who bought land in the western areas of Romania, i.e. in Timiş, Arad, Bihor, Satu Mare and Sălaj counties, where they have permanently moved their flocks to, while preserving their old residences.

In the autumn of 2014, mentioned is made of the transhumant movements of four owners from Jina, with flocks that totalled 2,750 sheep, to settlements in Bihor, Maramureş and Sălaj counties.

The Sibiu Veterinary and Food Safety Department approved the following movement routes:

- Jina (Sibiu County) – Teiuş (Alba County) – Lana (Cluj County) – Hezeclean (Sălaj County) – Tria-Derna (Bihor County);
- Jina (Sibiu County) – Ocna Mureş (Alba County) – Floreşti (Cluj County) – Jibou (Sălaj County) – Oarţa de Jos (Maramureş County);
- Jina (Sibiu County) – Blaj (Alba County) – Bontida (Cluj County) – Jibou (Sălaj County);
- Jina (Sibiu County) – Blaj (Alba County) – Turda (Cluj County) – Mirşid (Sălaj County).

The transhumant movements of nine owners, from Poiana Sibiului commune, with a flock of 3,500 sheep, are recorded on the route: Poiana Sibiului (Sibiu County) – Ocna Mureş (Alba County) – Jibou (Sălaj County) – Satul Barbar Village (Bihor County) – Tăşnad (Satu Mare County) – Salsig (Maramureş County).

Pastoral life in the rural area of Mărginimea Sibiului has a cyclic character, in terms of the four seasons. The cold season is the most difficult one for shepherds, because vegetation missing, sheep maintance is expensive.

Wintering lasts from November or December (depending on snowfall time), and March (when the first blades of grass appear). During this interval, small sheep flocks are usually sheltered in household sheepfolds, enclosures, inside or outside the village hearth, in huts, where hay is stored for the winter. Large flocks spend the winter at greater or smaller distances from the village, either in the village neighbourhood counties (small transhumance), or in the plains (big transhumance).

The pastoral year begins in spring, usually in April, when the flocks are brought around the village hearth, being sheltered in moving sheepfolds, on the adjacent pastures and meadows. For those who participate in big transhumance, it is the season of return to the residential village to prepare for the warm season.

Summer represents the most favourable season for pastoral life, then the flocks are led up to the alpine pastures. It is the period when milk products, especially cheese, are prepared. For shepherds, summer lasts from May – June to August –September, depending on the weather. More specifically, this pastoral cycle begins on the 21st of May, when the Orthodox calendar celebrates the Saints Constantine and Helena and ends between August the 15th (Assumption of the Virgin Mary) and the 8th of September (Birth of the Virgin Mary), when the weather starts cooling. The most important pastoral events of this period are: Shearing Lambs on the 20th of July (St. Elias) and the First Sharing of Cheese on August the 15th.

In summer, pastoral activities are going on around the sheepfold, in the alpine area. Autumn spans the interval between September – October and November – December, until snow begins falling. Now, the flocks are ushered from the mountain back to the village, where they move in enclosures or sheepfolds to fertilize the soils.

The most representative villages for pastoral activities in Mărginimea Sibiului are Poiana Sibiului, Jina, Tilişca and Răşinari. There are a series of customs and traditions practiced in these villages, which denote the pastoral specific and man's integration with nature. The Jina oscillation movements, or annual transhumance, is reflected by the so-called *custom of the huts*, where the shepherds use to stop on their way to the mountain pastures, staying at the huts until the beginning of summer. Women and children remain in the village and after the school-year ends, they also go up to *the huts*. In late June-early July, they mount to the pastures. Another custom, commonly practiced in Jina, is connected with the return of the flocks from the mountains to the pastures around the village, at the beginning of autumn; it is called *slobozatu hotarului de jos* (descending to the lower boundary) and is held on September the 8th, on the feast of the Birth of the Virgin Mary.

In Poiana Sibiului, when shepherds prepare to take the sheep go up the mountain in spring, villagers mark the event by a *Country Fair on the 5th of March*. This is the moment when shepherds wean the lambs and usher the flocks to the mountain. Another fair is held on their return in autumn, on the 19th of September. At Tilişca, the movements of flocks between village and mountain are also marked by customs and traditions, such as *the Feast of the Shepherds from Tilişca*, held on the 15th of August, on the occasion of the Assumption of the Virgin Mary. Therefore, all human activities in these villages with pastoral tradition show the permanent relationship with nature, the dependence on nature and, at the same time, the perfect integration of man into this system.

5. CONCLUSIONS

The hilly-mountain rural space of southern Transylvania is characterized by the great expansion of pastures and meadows to the detriment of agricultural land, a phenomenon that justifies the practice of primary activities, especially animal husbandry. Shepherding is the traditional occupation specific to the villages from Mărginimea Sibiului, a phenomenon that has influenced the social life and the economic characteristics of this region. A key element for the preservation of sheep-breeding traditions is the absence of forced collectivization in some localities which have very little arable land.

Transhumance is a process that has established certain links between generations engaged mainly in animal husbandry, an occupation practiced ever since the Antiquity, with a peak period in the 18^{th} and 19^{th} centuries. Small transhumance goes on in Mărginimea Sibiului neighbourhood and in the neighbouring counties (Alba, and Mureş); there is also big transhumance, when shepherds and their flocks use to spend the winter in the lowlands, both in the west and in the south or southeast of Romania. Some sheep-owners used to move their flocks abroad, travelling on the territories of other countries, such as Bulgaria, Turkey and Ukraine, and occasionally as far as the Caucaus area.

The modernization of society in the 20^{th} century, industrialization and urbanization, along with the establishment of a restrictive political regime and a central-based economy, had considerably reduced the phenomenon of transhumance, which became increasingly rare. The decline was exacerbated after 1990, when land owned by the state was restituted to their former owners, and private property was instituted, thus hindering shepherds from travelling over long distances.

However, there are still sheep-owners who currently move the flocks annually, especially in the West Plain and Hills, in the counties of Timiş, Arad, Bihor, Sălaj, Satu Mare and even Maramureş. Most of them come from Poiana Sibiului, Jina, Răşinari and Tilişca, where grazing grounds are limited by the presence of vast forest areas, or reduced communal territories. There are families who, although have kept their residence in Mărginimea Sibiului, used to buy agricultural land in the West Plain, moving their flocks there permanently, where the climate is warmer and the vegetation period lasts longer.

Therefore, transhumance remains a traditional phenomenon specific to the rural Carpathian space, where the ecological advantage of preserving and conserving the pastoral vegetation is closely-related to the ethno-cultural charactersitics engendered by discharging pastoral activities.

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SOCIO-ECONOMIC DEVELOPMENT
IN THE DANUBE DELTA BIOSPHERE RESERVE

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Key-words: Danube Delta Biosphere Reserve, socio-economic, sustainable development.

Abstract. Romania plays an important part in the EU Danube Region Strategy as co-ordinator country together with Austria. Its main goal is the socio-economic development of the Danube Region with strict observance of environmental protection principles. It is a priority task of this country as most of the Danube Delta Biosphere Reserve lies on its territory, a unique ecosystem in Europe and one of the largest natural wet zones in the world that has a threefold protection statute: UNESCO World Natural and Cultural Heritage Site, Wet Zone of International Importance (Ramsar Convention) and Biosphere Reserve of the "Man and Biosphere" UNESCO Programme. The Danube Delta Project aims at striking a balance between protecting this unique natural and cultural heritage and meeting the aspirations of the local population for better living conditions by creating the best opportunities for its economic development.

1. INTRODUCTION

The Danube Delta is a restrictive geographical space, with physical geographical constraints (water-emersed areas restricting settlement, specific water-governed soils and vegetation) and relational constraints (peripheral position, isolation, little accesssibility). Its particular landscape and landform ask for a special type of human settlement and economic development.

Declaring the Danube Delta a Biosphere Reserve has engendered socio-economic changes, the local communities and economies having to adapt themselves to environmental conditions.

As known, the Danube Delta Biosphere Reserve, implicitly the Danube Delta, are one of the most representative wet zones in this country and in the world, large areas having a protection regime. At the same time, works are underway to renaturate the wet zones turned over the years into agricultural land, eventually proving to be inefficient.

The socio-economic situation of the locals is affected by this restrictive geographical space (e.g. frequent flooding when the Danube overflows, or lasting periods of drought), people being vulnerable to environmental changes.

The Danube Delta population is a vulnerable social segment because of the difficult living conditions imposed, in general, by natural factors, but also by the inappropriate economic and technical-urbanistic infrastructure. Prospective solutions have in view to identify and elaborate ways and means of improving the quality of life and create socio-economic activities adequated to this space.

In order to obtain a balanced socio-economic development and environmental protection in the area, the Administration of the Danube Delta Biosphere Reserve and the Ministry of Regional Development and Public Administration initiated (by Government Decision) the Danube Delta Strategy Project for the 2011–2015 period. This Strategy set a series of general targets to raise people's living standard by making best use of local economic and cultural assets, at the same time protecting the Deltaic environment. Several other specific areas, falling under this Strategy, are education, health-care, transport, infrastructure, tourism, culture, agriculture and regional development. However, fulfilling these specific tasks means securing the Delta population stability.

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2. THE CURRENT DEMOGRAPHIC SITUATION IN THE DANUBE DELTA

The present settlement system in the area consists of only one town – Sulina, and seven communes, that is, 23 settlements in all with a population of over 10,706 inhabitants (2011 Census data) (Fig. 1).

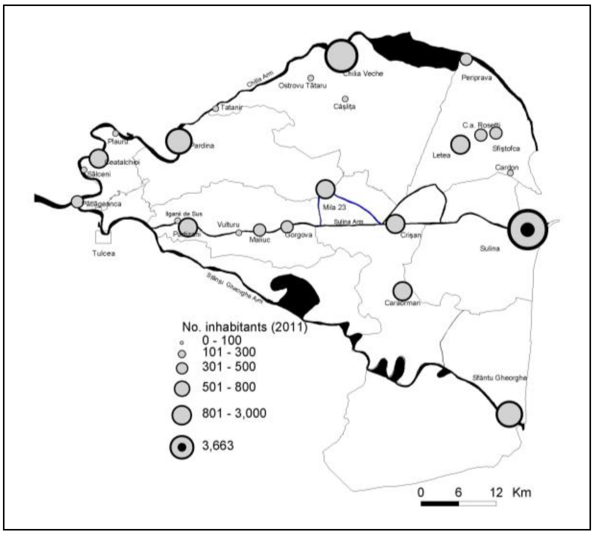

Fig. 1 – The Danube Delta settlements by number of inhabitants.

These data show a decreasing trend compared to previous censuses, due both to a negative natural balance and to population migration, a phenomenon affecting all of Romania. In-between the 1912–2011 censuses the Delta lost over 7,000 inhabitants, numbers rising in 1966 (20,421), when complex programmes of turning the area agricultural and fish-rearing had attracted numerous specialists and workers; a similar situation (mild numerical increases) happened also after 1997, when industrial restructuring, associated with mass remittances, made people return to the Delta.

Also Sulina Town, the only urban settlement in the Danube Delta, experienced emigrations when some economic activities came to a halt and young people, in particular, started looking for a job in the better economically developed cities of Tulcea, Brăila, Galaţi and Constanţa, (2011Census figures show Sulina to have 3,663 inhabitants).

Looking at the age and sex structure, it is obvious that demographic ageing affects all deltaic settlements, especially the more isolated ones situated far from the main water transport routes (Fig. 2).

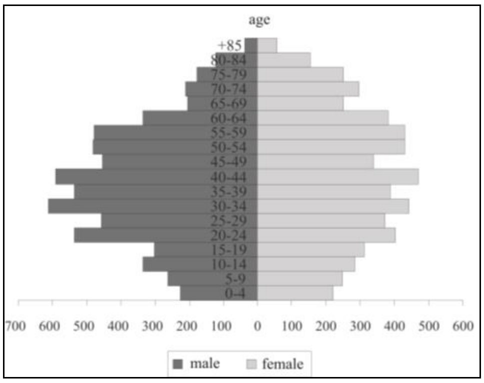

Fig. 2 – The age and sex structure.

3. THE LOCAL ECONOMY. CHARACTERSTICS

The main occupation in the Danube Delta, beside fishing practiced for some 6 months/year, is agriculture (which meets local needs) and agro-tourism from June to September. In some settlements, the absence of arable land hampers the practice of agriculture (Sfântu Gheorghe, Crişan, Mila 23), the locals cultivating only the patch of land around the house for family consumption. Some families use to make a living mainly from tourism, but they are rather an exception. The majority are engaged in both activities, with a variable share in the family income. With the exception of public institutions, jobs are a rarity, available only in a few shops, bars, restaurants, bakeries and boarding-houses; worst-off people work by the day in garden digging, or in the building sector of holiday houses, in particular (F. 42-years old says "when there is a job to do, we go there to do it").

Economic problems of the local population

The main problem is absence of investments, hence of jobs for young people, in particular. Finding work in the towns adjoining the Delta is pretty difficult, because work-places are scarce there, too, commutation is very expensive and unemployment is high throughout the area. Major problems facing the Delta rural communities are little employment for the workforce and low incomes (Table 1).

Table 1

The active population structure, number of unemployed and unemployment rate (2011)

Localities	Total population	Active population	Of which: employed population	Inactive population	Unemployed	Unemployment rate (%)
Sulina	3, 663	1, 807	1, 605	1, 856	202	11.2
C.A. Rosetti	910	454	424	456	30	6.6
Ceatalchioi	593	349	341	244	8	2.3
Chilia Veche	2, 132	797	747	1, 335	50	6.3
Crisan	1, 228	534	516	694	18	3.4
Maliuc	856	452	441	404	11	2.4
Pardina	527	256	250	271	6	2.3
Sfântu Gheorghe	797	387	366	410	21	5.4

4. INFRASTRUCTURE AND DEVELOPMENT OPPORTUNITIES

Education. The quality of life is significantly related to and dependent on education and skills. There are few university graduates and qualified teachers are missing (dwelling conditions being improper for the needs and demands of this socio-professional category). Most pupils being poor prevents them from going on to secondary school.

The material endowment of the Delta settlements differs from place to place, inexistent in small and very small settlements and relatively good in communal centres (compared to the small number of pupils/1,000 inh.), where schools and kindergartens do exist (Table 2).

A number of five out of the eight schools and kindergartens have their own microbuses to take pupils from villages to the communal centre over a distance of 3–14 km. In isolated villages, which microbuses cannot reach, the only transport means are the channel boats. Sofar now, the Danube Delta has no accommodation facilities in boarding-schools, or weekly programmes in school campuses to offer pupils optimum learning and dwelling conditions (*Danube Delta Strategy, 2011–2015*).

The main education problems involve the functional optimisation of the school network, adjust the offer to the needs of the local labour market and produce better trained and skilled people.

Table 2

Educational infrastructure (2011)

Localities	Schools	Enrolled pupils	Teachers	Teachers/ 1,000 pupils	Class-rooms	Graduates	No. PC
Sulina	1	496	33	66.53	18	74	49
C.A. Rosetti	1	97	13	134.02	10	7	18
Ceatalchioi	1	57	4	70.18	4	5	12
Chilia Veche	1	236	16	67.8	9	24	10
Crişan	1	129	16	124.03	10	16	8
Maliuc	1	73	11	150.66	11	5	14
Pardina	1	65	6	92.31	3	10	16
Sfântu Gheorghe	1	64	7	109.38	5	5	11
total	**8**	**1,217**	**106**	**814.92**	**70**	**146**	**138**

Data source: http://www.insse.ro

Health. Another major goal to develop and stabilize of the Delta population is the health-care infrastructure which, together with education, are key development elements in any society.

Medical assistance in the Danube Delta is provided by 7 family doctors under contract with the County Health Assistance Chamber (Table 3).

Table 3

Health infrastructure (2011)

Localities	Inhabitants	Doctors	Doctors/ 1,000 inh.	Family doctors	Dentists	Chemists	Nurses
Sulina	3,663	8	1.9	2	3	1	10
C.A. Rosetti	910	0	0	0	0	0	0
Ceatalchioi	593	0	0	0	0	0	0
Chilia Veche	2,132	3	3	2	1	0	1
Crişan	1,228	1	1	1	0	0	1
Maliuc	856	1	1	1	0	0	0
Pardina	527	0	0	0	0	0	0
Sfântu Gheorghe	797	1	1	1	0	0	0

Data source: http://www.insse.ro

Specialist medical assistance is available in county hospitals; there is an emergency assistance service with 5 motor-boats, equipped with medical facilities, that can cover the distance between the towns of Tulcea-Sulina and Tulcea-Sfântu Gheorghe in about an hour's time. In winter (when the Danube is frozen), an ice breaker, or a SMURD helicopter are used in emergency situations.

The medical material basis is unsatisfactory, consulting rooms function only in Sulina Town and in the communes of Chilia Veche, Crişan, Maliuc and Sfântu Gheorghe;, the town's hospital had been closed down in 2011, an emergency section, subordinated to Tulcea County Hospital, was opened in 2012. The town also has two drug-stores.

Health services in the Danube Delta have to cope with difficult access and doctors' disinterest for the local population, not very numerous either and low-income, too; moreover, many people have no medical insurance.

As a conclusion, the main health problems involved establishing medical assistance networks in all of the Delta communes, increasing the quality of medical services, and informing people on access facilities to medical services.

Transports. An important element are an important element of access which the area's socio-economic development depends on. The Danube Delta localities are connected by inland navigable waterways, regular passanger and commodity cruises on the three arms of the Danube being scheduled by NAVROM DELTA Company. Noteworthy, persons that have a stable domicile, a work-place or discharge activities in the Danube Delta settlements and in Tulcea Town, provided they possess conclusive documnets to attest it, benefit from subsidised tariffs. Apart from NAVROM-based transport, there are also private companies engaged in transport schemes between the Delta settlements. However, charges are much higher and there are no regular scheduled hours, which depend on passanger traffic.

Road transport outside county boundaries is provided by daily return bus drives from Tulcea to Bucharest, Constanţa, Galaţi, and Brăila.

Rail tansport between Tulcea and Medgidia is difficult and overdue, this section needs updating and the line electectrefied. Besides, a bridge across the Danube at Brăila would facilitate the access of Tulcea County and the Delta settlements to the other regions of Romania (*Danube Delta Strategy, 2011–2015*).

In the absence of road connection facilities between Tulcea Town and the Delta, locals find it difficult to sell their own products in the market, an activity which for many represents the principal income source of the family. Also, the absence of transport means in the Delta could have negative effects on the population's living standard, being a drawback to some economic activities, or to tourism.

An older desideratum of the Delta inhabitants is to have inland access roads, whatever the weather conditions, to the economic and social services of Tulcea Town. However, a World Bank study shows that road-building depends both on financial possibilities and on the environment (*Diagnostic Report. Integrated Strategy of the Danube Delta Sustainable Development.* Project co-financed by the European Fund for Regional Development through the agency of POAT, 2007–2013).

Major transport-related priorities to promote the Danube Delta socio-economic life and tourism in this area imply finding solutions for the transport of people and commodities; improving roads, especially those running from Bucharest and from the sea-side so as to connect sea-side tourism with Danube Delta tourism; setting a time-schedule for Tulcea airport, only occasionally operated at present; building a tourist harbour in Tulcea, only for agreement boating, and tourist harbours in Sulina Town and in the settlements of Crişan and Sfântu Gheorghe.

Tourism. A Danube Strategy priority is to put to advantage the area's natural and cultural assets. Once the Danube Delta was declared a Biosphere Reserve, reorganising its tourist activities required the sustainable use of its natural resources and of the landscape, in particular. The area's impressive tourism potential is not sufficiently exploited, a tourism development strategy is missing, instead only actions of organising and implementing ecotourism are in place as the best form of tourism in a protected zone.

The Administration of the Danube Delta Biosphere Reserver (ADDBR) designated 9 tourist zones available on 15 water routes and 9 on land routes, tour operators being obliged to use them. Tourist services operators and the tourists themselves must protect the deltaic ecosystems and reduce the negative impact of tourism on the environment.

The tourist infrastructure in the Delta consists of the technical-material basis of deltaic settlements and of Tulcea Town: transport, accommodation, amenities and public catering. Most hotels are located in Tulcea, the gateway to the Delta; there is one hotel in Sulina, one at Crişan, and several boarding-houses and tourist villas in the settlements of Crişan, Sfântu Gheorghe, Mila 23, Vulturu, Gorgova, Chilia Veche, Periprava and in Sulina Town.

Accommodation capacity values over 2001–2013 indicate a mild increase after 2004, and a slight decrease in the years 2009–2010. Noteworthy, no officially registered beds in rural tourist boarding-houses, agro-tourist boarding-houses and in floating hotels had existed until 1998 (Fig. 3).

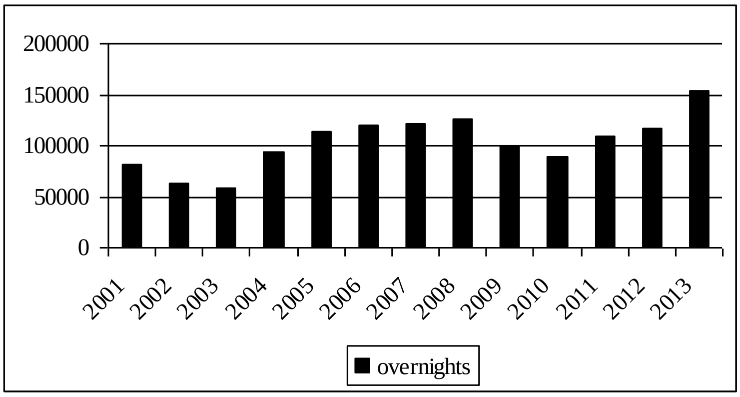

Fig. 3 – Overnights (2001–2013).

As a result of promoting deltaic tourism at home and abroad, of increasing the accommodation capacity, and offer better services, the number of tourists who chose vacationing in the Delta was resing. Romanian tourists prefer sojourn programmes, while foreign tourists opt for trips (Fig. 4).

Landscape diversity and traditional settlements windened the range of tourism opportunities and forms: rest and recreation, discovery, water sports, sporting fishing, sporting hunting, scientific tourism, rural tourism, ecotourism, etc. (Photo 1).

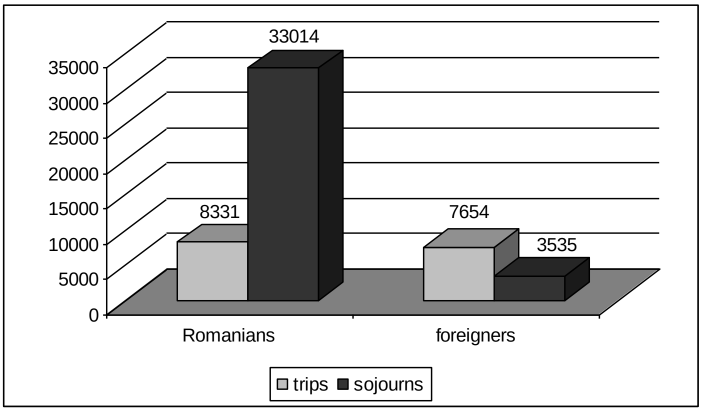

Fig. 4 – Tourists' preferences:sojourns and trips.

Photo 1 – Watch tower.

Likewise other domains, also tourism must solve a series of problems in order to improve its offer, e.g. have drinking-water networks and waste dumping-sites in all settlements, registration services for incoming tourists, homologated boarding-houses at standard levels and, last but not least, solve problems of transport and access, especially to the deltaic settlements, as well as from Bucharest to Tulcea.

Local communities should be stimulated to develop ecological tourism, which promotes local customs and traditions, rather than large-scale tourism which is extremely detrimental to the environment.

Culture is an important component for the population's socio-economic progress. A UNESCO World Natural and Cultural Heritage Site, the Danube Delta has numerous assets, among which are the customs and traditions of the locals, and of each minority in the area, the arhitecture of Sulina Town arhitecture but (buildings need repair and conservation works) (Photos 2, 3).

Photo 2 – The old lighthouse.

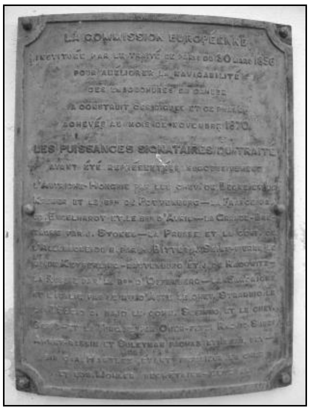

Photo 3 – Memorial plaque of the European Danube Commission.

Sulina, the only town in the Delta, played host to some cultural and artistic events: e.g. the National Festival of Musical Creation and Interpretation; the 'Delta Feasts' Festival of the National Minorities; Conservation and Valorisation of the Danube Delta Folklore.

As of 2003, Sfântu Gheorghe settlement has become the traditional host of the "Anonimul" Independent Film Festival, an attraction for ever more tourists by the year.

Also cultural activities need improving by rediscovering the practice of traditional handicrafts, (especially the processing of reed), developing cultural tourism, protecting and conserving the built heritage (Photos 4,5).

Photos 4,5 – Reed and its uses.

Beside the general and specific targets discussed herein, which should be observed in order to maintain the stability of the Delta population and its social and economic activities, some of the risks attached to the area, and the vulnerability of its population to climate change, must not be overlooked either.

5. RISKS AND VULNERABILITIES

Analysing the Danube Delta's socio-economic and demographic situation has revealed some risks and vulnerabilities of the local population to certain external factors. A fisrt risk is depopulation of the country-side, with already significant losses in the settlements of Caraorman, Cardon, Sălceni, Plauru, Sfiştofca and Vulturu, a situation caused here by isolation, deficient access infrastructure, job shortage and long distances to industrial centres. Isolation is a high risk in wintertime when floating ice and ice bridges might form, while the earthen roads, even if they do exist, become impracticable under heavy rain or snowfall. Economic risk comes from the fragmentation of agricultural land and its improper use, lack of irrigation systems, obsolete farming equipement, little access to the funds earmarked to farming, and poor representation of the associations of producers.

Having in view that the Danube Delta is a place of special interest for tourism, environmental and natural protection, careful observance of natural habitats and optimum use of cultural availabilities and traditions, as well as people's health condition and security, be they locals, Romanian or foreign tourists are of paramount importance. Therefore the Danube Strategy aims to create a risk prevention service, little developed so far because of access difficulties, given that many settlements can be reached only by waterway (canals, backwaters). Besides, measures should be taken to prevent the consequences of frequent exposure to natural risks (floods, droughts, earthquakes, etc.), technological and anthropic risks (e.g. arson of reed over large areas) with dramatic effects on the environment, natural habitats and protected natural areas. Therefore, elaborating projects to improve the capacity of the emergency professional staff in matters of prevention and control, as well as in emergency situations in the Danube Delta area and in the other Danube reparian counties, is an imperative demand *(http://www.mae.ro/sites/default/files/file/userfiles/file/pdf/UE/Str_Dunarii_NonPaper.pdf*).

Another problem the Global population must cope with, is climate change, visible also in the Danube Delta, where lasting droughts and floods have become ever more common; it is only Sulina Town and the settlements of Tudor Vladimirescu, Crişan, Mila 23, Caraorman, Sfântu Gheorghe, Maliuc, Ilganii de Sus and Pardina that are partly protected by dams (Photos 6,7).


Photos 6,7 – Protection dams in the settlements of Mila 23, Crişan.

Particularly vulnerable to climate change are the poor populations, those with no stable incomes for a decent living, the great many unemployed, the aged without social assistance benefits, etc. This is also the case of the Delta people. The effects of climate change (if temperatures rise by 1.5^0–2^0 C) will be felt by the local communities whose welfare depends on the area's water and food resources; at the same time, also natural ecosystems and the Delta's unique biodiversity are going to suffer (*wwf.panda.org/dd_climate_adaptation. Vulnerability of the Danube Delta Region to Climate Change*).

6. CONCLUSIONS

The analysis of the deltaic space in terms of population, economic and social activities, endowments, accessibility, quality of the environment, conditions of life and work shows that there are still many problems to be solved in order to create normal living conditions in this area.

A brief overview reveals the steady numerical decrease of inhabitants through low birth-rates and emigration of the young population looking for a job elsewhere, an ageing workforce, large numbers of inactive people and of unemployed. Economic activities are limited mainly to turning to account local natural resources.

Development priorities in the Delta should focus on creating better education and health services, which means having a more qualified teaching staff, a functioning school network, and primary medical assistance extended to communal level.

The transport agenda includes solutions to organise navigation and shorten sailing time on the three arms of the Delta, but also to develop and update land routes, improve navigation security on the Danube arms and canals and impose restrictions to prevent water pollution by ships. Apart from the transport infrastructure, the technical-urbanistic infrastructure needs improving, too, by connecting all settlements to the drinking-water network, extend the used-water collecting network and find solutions to dumping household refuse.

The tourist sector should encourage the practice of ecological tourism and the balanced development of the entire Delta tourist zone, a first step in this direction having been made by building a mini-harbour at Sfântu Gheorghe. The tourism infrastructure of Sulina Town and of the Delta tourist sites should be improved.

Among the area's assets we would recall its great biodiversity, the wide range of habitats and forms of life which make the Danube Delta the best known exemple where there is a large number of floristic and faunistic species worth-conserving. A positive action is ecological reconstruction in order to remake the deltaic environment and bring it as close as possible to its initial state.

The Danube Delta plays an important role in the Danube Strategy given that it administers most of the Danube Delta Biosphere Reserve, the youngest territory of the Danube Basin and a unique ecosystem in Europe, listed since 1991 as UNESCO site of mankind's cultural heritage.

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THE INTERNATIONAL GEOGRAPHICAL UNION REGIONAL CONFERENCE AUGUST 17–21, 2015, MOSCOW, RUSSIAN FEDERATION

One of the foremost scientific events of the world's geographical community in 2015 was the **Regional Conference of the International Geographical Union (IGU)** which was held in Moscow, Russian Federation (17–21 August), for the third time since the International Geographical Congress in 1976. The central theme of this event was "*Geography, Culture and Society for Our Future Earth*", a topic with tight connections with the global international research platform which supports interdisciplinary approaches on global environmental change – *Future Earth*.

The IGU Moscow Conference was jointly organised by the Institute of Geography of the Russian Academy of Sciences and the Russian Geographical Society and was held at the Lomonosov Moscow State University under the patronage of Dr. Vladimir Kolosov, the incumbent president of International Geographical Union. The main areas covered by this scientific event were: urban environments, polar studies, climate change, global conflicts and regional sustainability. Noteworthy is that the conference coincided with the celebration of the 170th anniversary of Russian Geographical Society.

This prominent event was attended by over 1,650 participants from 73 countries, the largest groups originating in Russia, China, India, USA, Japan and Germany. From Romania, researchers and professors form the Institute of Geography, Romanian Academy, the Faculty of Geography, University of Bucharest the Faculty of Geography and Geology, "Alexandru Ioan Cuza" University, Iaşi and Faculty of Geography, Babeş-Bolyai University, Cluj were present. Throughout the conference, the IGU Commissions and task forces integrated their business meetings on the current topics of modern geography and the participating scientists displayed their scientific results during the Plenary Sessions, as well as during Commissions sessions (e.g. Local and Regional Development, Land use and Land cover change, Biodiversity and Biodiversity, Political Geography, Urban Challenges in a Complex World, Distributed Spatial Data and GIS, Geographical Systems' Modeling, Natural and Anthropogenic Risks and Hazards, Contemporary Geographical Technologies, Sustainable Land and Water Use). Therewith, two sessions were devoted to the work on the flagship IGU projects, i.e. International Year of Global Understanding (IYGU) and Our Sustainable Cities (Oursus). Overall, the scientific programme included 312 scientific sessions consisting of 1084 individual oral presentations and 451 poster presentations.

The conference agenda also included different workshops and interdisciplinary field trips organised by the IGU Commissions and the Conference Steering Committee in order to allow the participants to get in touch with the particular features of the Russian natural and cultural landscape.

Associated to this event was the 12th edition of the International Geographical Olympiad (iGEO) which was organized in the region of Tver and in Moscow. The 2015 theme of the Olympiad was "*Challenges of Contemporary Urban Areas*". Once again, the Romanian Geography obtained a remarkable success, thus being awarded with four medals: one gold, two silver and one bronze, ranking first among the participating countries.

On behalf of the Institute of Geography, Romanian Academy three scientific papers were presented: "*Invasive terrestrial plant species in Romanian protected areas. Key environmental features and spreading pathways*" (M. Dumitraşcu, I. Grigorescu, Gh. Kucsicsa, M. Doroftei), "*Post-communist urban sprawl related built-up dynamics in the Bucahrest Metropolitan Area*" (I. Grigorescu, Gh. Kucsicsa, B. Mitrică, I.Mocanu) and "*Water demand for the main agricultural crops under climate change impacts in the Oltenia Plain. Romaniatudies*" (B. Mitrică, C.S. Dragotă, I. Grigorescu, M. Dumitraşcu, E. Mateescu).

The next foremost global geographical event will be the ***33rd International Geographical Congress*** which will be held in Beijing, P. R. China, August 21–25, 2016 with the theme "*Shaping Our Harmonious Worlds".*

Monica Dumitraşcu, Ines Grigorescu

Rev. Roum. Géogr./Rom. Journ. Geogr., **60**, (1), p. 109–111, 2016, Bucureşti.

WARSAW REGIONAL FORUM 2015 TERRITORIAL UNCERTAINTY AND VULNERABILITY AS A CHALLENGE FOR URBAN AND REGIONAL POLICY, POLAND, OCTOBER 14–16, 2015

On October 14–16, WARSAW REGIOAL FORUM 2015 *Territorial uncertainty and vulnerability as a challenge for urban and regional policy* was organized by the Institute of Geography and Spatial Organization of the Polish Academy of Sciences in collaboration with the Ministry of Development and Polish Geographical Society.

The principal topic of the Conference was concentrated around such problems as vulnerability, uncertainty and resilience of territories. The subject of discussion was the threats of an economic (global crisis), environmental, institutional and geopolitical nature. These issues were analyzed in the light of multiple spatial scales at European, transborder, national, regional, urban and local levels. The Conference topic fits well into the current ongoing debate over spatial development that takes place in the EU, combining academic discussion with presently territorial policies carried out, including especially the policy of cohesion.

In particular, the nine Sessions of the Forum focused on discussions regarding the following dilemmas and research questions: Vulnerability and resilience of cities/towns; Resilience of natural the environment to spatial and economic changes; The role of infrastructure in promoting the development and safety in the regions; Stability of local development vs. regional and European policy; Social transformations vs. instability of development; Public management under varied social and economic conditions.

The participants came from several counties: Poland, Germany, Hungary, Italy, Slovakia, Israel, Austria, Romania, and Ukraine, as well as from different fields, such as geography, economy, sociology, regional studies, spatial planning, environmental studies, etc. Three papers were presented by the authors from the Institute of Geography of the Romanian Academy: *Spatial and temporal dynamics of urban sprawl in Bucharest Metropolitan Area over the past century* (Ines Grigorescu, Gheorghe Kucsicsa, Bianca Mitrică, Irena Mocanu), *Competitiveness, cohesion and sustainability in the urban development of the Romania's border regions* (Bianca Mitrică, Monica Dumitraşcu, Irena Mocanu, Ines Grigorescu), *A preliminary approach to the assessment of socio-economic vulnerability to dryness and drought phenomena in Bucharest Metropolitan Area* (Irena Mocanu, Bianca Mitrică, Ines Grigorescu, Carmen Dragotă, Monica Dumitraşcu).

The field trip organized on October 14, in the southern metropolitan area of Warsaw, occasioned some meetings to be held between participants in the Conference and representative from various institutions that play an important role in local development. Thanks to a diverse group of speakers, the participants had the opportunity to confront their own theoretical knowledge with the practicalities of regional and local development. The study trip provided the possibility for discussing the rapid development of the suburban zone south of Warsaw, the natural and agricultural landscape near Warsaw, new road investments, the present-day situation of fruit producers, social disparities in the metropolitan area and governance at local level.

Bianca Mitrică

INTERDISCIPLINARY RESEARCH-INNOVATION RELATED TO THE EU STRATEGY FOR THE DANUBE REGION SYMPOSIUM
NOVEMBER 10–11, 2015, BUCHAREST, ROMANIA

The fourth edition of this international Symposium, hosted by the Romanian Academy, was organized by the Institute of Geography of the Romanian Academy, the National Research and Development Institute for Marine Geology and Geoecology – GeoEcoMar, the National Committee for "*Future Earth–research for global sustainability*", the Institute of Biology of the Romanian Academy, the Danube Delta National Institute for Research & Development, and the National Institute of Research and Development for Biological Sciences.

The Symposium was organized within the framework of the '*Development Strategy of Romania for the next 20 years – The European Danube Project/The National Danube Strategy – Priority Project no. 8*', developed under the Romanian Academy aegis over the 2015–2016 period. This event was attended by specialists from various Romanian and foreign research institutes and universities from Germany, Switerland, Poland and Romania.

The Symposium focused on interdisciplinary research related to the four pillars of the EU Danube Strategy – connectivity, environmental protection, economic development and governance. A special topic targeted macro-regional issues aimed at ensuring territorial cohesion and future sustainable development within a socio-economically diversified space connected with the Research Programme Horizon 2020 and with the "*Future Earth – research for global sustainability"* Programme.

Updated information, focused on several main international projects was discussed with special attention to the following: National Scientific Research and Innovation Strategy for the Romanian Danube Region (N. Panin, Romanian Academy, Bucharest); International Centre for Advanced Studies on River-Sea systems – DANUBIUS – RI (A. Stănică, M. Sidoroff, National Research and Development Institute for Marine Geology and Geoecology and National Institute of Research and Development for Biological Sciences); Global Change Atlas of the EU Strategy for the Danube Region – a tool for the stakeholders in the decision-making process (D. Bălteanu, D. Dogaru, M. Dumitraşcu, I. Nichersu, B. Mitrică, M. Jurchescu, M. Sima, Institute of Geography, Romanian Academy, Danube Delta National Institute for Research & Development); Sturgeon conservation in the Danube River Basin – a complex environmental-economic-social approach (C. Sandu, O. Popescu, R. Suciu, Institute of Biology, Romanian Academy, Danube Delta National Institute for Research & Development).

Of special scientific interest proved to be the papers on the Impact2C Atlas (S. Preuschmann, Climate Service Center Germany); in need of partnerships – environmental computing and European e-Infrastructures (A. Frank, Leibniz Supercomputing Centre, Bavarian Academy of Sciences and Humanities); and the GLOCAD network – International collaboration for Global Change research in the Danube Region (M. Muerth, Ludwig-Maximilians University, Munich);

The issue of sturgeons focused on the following: the need for trans-national implementation of Sturgeon Action Plan objectives (H. Rosenthal, University of Kiel, Germany, President World Sturgeon Conservation Society); a scientific approach to ensure and restore the river continuum for migrating sturgeons in the Danube (J. Bloesch, International Association for Danube Research).

This scientific approached to territorial cohesion in the Baltic See Region had in view a presentation of the EU Strategy for this region (M. Konopski, D. Mazurek, Institute of Geography and Spatial Organization, Polish Academy of Science).

Discussions pointed out new possibilities for interdisciplinary co-operation research into the Lower Danube Basin in close correlation with the economic, administrative and political stakeholders.

Bianca Mitrică

*** (2015–2016), *Strategia de dezvoltare a României în următorii 20 de ani* (Romania's Development Strategy over the next 20 years), Ionel-Valentin Vlad (ed.), Edit. Academiei Române, vol. I (480 pages), vol. II (462 pages), Bucureşti.

This Development Strategy was elaborated under a Project of the Romanian Academy coordinated by Acad. Ionel-Valentin Vlad.

Interdisciplinary teams of specialists from the Romanian Academy, from other research institutions, and higher education establishments have been assigned to each of the eleven areas of this Strategy.

The eleven chapter-based research themes (projects) found in this two-volume study focus on the most important, but also very vulnerable areas of this strategy: *School and Education; Natural strategic reserves, what we use and what we leave to future generations; Security and energy efficiency; Information security – cybernetic protection; Protection of intellectual property englobed in projects and electronic publications; Security and food security; Economy and quality of life; Health state – from Molecular Biology to Personalised Medicine in Romania; The National Danube Strategy; Romanian culture between the national, that is in the proximity zone and the universal; Multi-language Europe, electronic culture; Romania – Society of knowledge and of added value to what it has; Romania in the globalization era – Space and tradition, a meeting-place of civilisations, of equilibrium and moderation*.

The first volume provides a SWOT analysis of each tackled area, a general development outlook for time-intervals of 3–5, 10 and 20 years, as well as several scenarios of Romania's European integration. The second volume, proceeding from existing weaknesses presents a general view on the subject and sets a short-, intermediate, and long-term task-plan.

Geographical researches were integrated into two main domains: assessment of natural resources (air, soil and protected areas) and the National Danube Strategy, in the latter being proposed an Global Environmental Change Atlas of the Romanian Danube Valley.

The two volumes overviewed herein are devoted to the anniversary of 150 years from the foundation of the Romanian Academy.

Elena Teodorescu

*** (2015–2016), *Resursele strategice ale României* (The Strategic Resources of Romania), Bogdan C. Simionescu (ed.), *Volumul 1. Problemele prezentului şi provocările viitorului* (Volume 1. Current problems and future challenges), 197 p., *Volumul 2. O abordare pentru următoarele două decenii* (Volume 2. An approach to the next two generations), 213 p., Edit. StudIS, Iaşi.

Under the aegis of the Romanian Academy, a two-volume book on *The Strategic Resources of Romania*, co-ordinated by Academician Bogdan C. Simionescu was published in 2015 and 2016. The first volume, *Current problems and future challanges*, deals with a highly topical issue, namely, the responsible, sustainable use of the main environmental components (air, water, soil, forests, and subsoil resources). An analysis of protected areas points out that, over the years, man's impact on nature has created major imbalances among the environmental elements. The management of all type of wastes is also a very topical problem, tackled by the authors in relationship with their impact on health and on the environment. Last but not least, the demographic question is also broached, demographic forecasts providing for a numerical outline of future generations. A SWOT analysis targets each component, with highlight on the situation Romania is expected to attain in 2035.

The second volume, *An approach to the next two generations*, proceeds to setting some main goals, that is, to identify priority sectors and task plans for each component discussed in this book, in conformity with current and future requirements. The final goal is for Romania to reach a high development level, and have this country occupy the place it deserves having in view its available resources.

These two volumes are part of the Project, *Natural Resources. Strategic reserves, what we use and what we leave to future generations* integrated into *The Strategy of Romania's development in the next 20 year, 2016–2035*. The eleven projects of this Strategy make an interdisciplinary approach to the fundamental sectors of the

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Romanian society, from education and economy to culture and international positioning, starting from the more careful conservation and valuation of this country's heritage.

The work of specialists from several research fields of the Romanian Academy and the University staff alike, the volume is addressed to a wide readership, both specialists and decision-makers, to eventually raise awareness of the importance and rational use of natural resources.

Nicoleta Damian

(2015), *Atlas of Land Use/Cover Change in Selected Regions in the World, Volume XI* (Atlasul Schimbărilor în utilizarea şi acoperirea terenurilor. Studii de caz în diferite areale de pe glob, Volumul XI), Ivan Bicik, Yukio Himiyama, Ján Feranec, Lucie Kupkova (eds.), Charles University in Prague, 70 p., in English.

The Atlas published by International Geographical Union Commission on Land Use and Land Cover Changes is a work that puts together the research results of universities and research centers in Romania, Slovakia, Poland and the Czech Republic focused on the dynamic of land use/cover. Often vulnerable to economic and political conditions, land use/cover undergoes significant changes that do propagate to the other components of the ecosystem. Knowing that the most intense land use/cover dynamics occurs in the urban, agricultural and forestry landscape, this work brings together studies of areas belonging to such landscapes: the Romanian Danube Valley, Bucharest Metropolitan Area, Bratislava, and the Prague metropolis, agricultural land in Czechia, the Gorce Mts. in the Polish Carpathians.

Environmental damage is assessed by using a specific methodology, depending on the ecosystem it is applied to, stressing upon the following issues: the amplitude and spatial distribution of changes in land use/cover (in the landscape of the Romanian Danube Valley or Gorce Mts.); dynamics of the built-up area in the Bucharest Metropolitan Area over the last century; the size and spatial distribution of areas affected by transitional dynamics or changes in land use/cover (in post-communist Romania); changes of artificial surfaces in urban areas (Bratislava), land cover (Prague metropolis) and agricultural lands (Czech Republic) are subject to.

The indicators were selected from the Eurostat database and satellite images available for researchers, so that these types of research can be applied to other European Union areas as well, thus attempting to achieve a harmonized methodology.

Overall, these researches succeed to create an image of changes in the dynamics of land use/cover, addressing, tangentially or directly, ecological concepts such as succession disturbance, and variability in the context of a human civilization where economic and political conditions are rapidly altering and entailing changes in the environmental components, thereby limiting further development options of the Planet's inhabitants. In some cases, such as the Romanian Danube Valley, the question arises as to damming the River-affected floodplain lakes, soil quality, topoclimate, and hydrological regime of the Danube. Even if the Atlas studies draw attention to environmental change by altering land use/cover, do we know Nature well enough to put the ”pieces” back?

Paul Şerban

Lucian David (2015), *Peisajele etnografice din România* (Ethnographic landscapes in Romania), Edit. Etnologică, Bucureşti, 191 pages, 57 figs, 57 photos, refers.

This editorial production, the result of lasting scientific investigations conducted into the Romanian geographical space by young researcher Lucian David, is based on a sound documentation of the ethnographic landscape types. The author's activity began in 2000 as doctoral candidate and continued also after 2010, when he was awarded the Ph.D. of Geography title. The 191 pages of this work include: Contents, Foreword, five chapters, bibliographical references, tables, 57 figures (maps, graphs, schemes) and as many photographs.

The author outlines the topicality of the subject (***Introduction***), considering that an analysis of the highly fragmented and fastly degrading ethnographic landscape in Romania is both of theoretical and practical value.

A noteworthy work on the list of David's publications is *Atlasul Etnografic Român*, elaborated in collaboration with specialists from the Institute of Ethnography and Folklore. This monumental achievement stands out by its original cartographic material. Each landscape, engendered by soil agricultural and non-agricultural uses, is shown on the thematic maps contained in the five Atlas volumes: I. The Habitat, II. Occupations, III. Popular Techniques, IV. Falk Art and Costume, V. Feasts, Customs, Mythology).

Having in view the above-mentioned scientific achievement and the author's contribution to it, the reader is expected to receive the five-chapter *Ethnographic landscapes in Romania* with special interest.

The analysis of numerous field information, questionnaires and statistical data highlights the multitude of ethnographic landscape aspects and typology illustrated by a rich cartographic and photographic material.

Chapter One provides some theoretical considerations on the Landscape concept, furthermore enlarging upon the Geographical Landscape. Proceeding from the recent definition of the term *landscape* given in the Explicative Dictionary of the Romanian Language (1998), the author makes a general presentation of the historical evolution of its use in painting and photography, as well as in ecology, architecture, geography and culture at large, also recalling Romania's membership of the European Landscape Convention.

Chapter Two. Its two sub-chapters are devoted to the cultural landscape values, underscoring the theoretical aspects of this landscape type (sub-chapter one) and research into the ethnological landscape (sub-chapter two).

Chapter Three, *The Ethnographic Landscape*, proceeds from analysing the definition and features of this landscape type, further presenting all its components and concluding with its hierarchisation.

Chapter Four makes a detailed presentation of the ethnographic typology, with focus on land use and, based on it, discusses each type of landscape: forest, pastoral, pomological (fruit-growing), viticultural (wine-growing), piscicultural (fish-breeding) and mixt. Maps, descriptions, quotations and thematic photographs complete the analyses made. Ethnographic landscapes are grouped by two large categories: primary and derived. The former (forest, pastoral and piscicultural) are described in detail in sub-chapter four; the latter, correlated with land-fond dynamics, are enlarged upon in three regional case-studies: the Rucăr-Bran Corridor in the mountain zone, the Cotmeana Piedmont in hillock and tableland zones, and the Oltenia Plain in the lowlands. The cultural ethnographic structures are discussed in terms of origin, evolution and religion. The state of conservation of ethnographic landscapes (regressive, unstable, stable and progressive), as well as their aesthetic value (spectacular, special and ordinary) are two interesting study-subjects of the last two sub-chapters.

Chapter Five assesses the Romanian ethnographic landscape and, together with Chapter Four, represents the core of the whole volume (over 60% pages and 80% of the graphic and photographic illustration). Here, one finds also an analysis of the geographical landscape and methods to appraise this landscape-type sustainable development. According to the author, a first step in landscape research is to outline the study-area (region, province, or village, and the cultural environment), get a knowledge of the geographical setting, diagnose the respective life environment (relief, waters, soils, climate, vegetation and fauna), as well as the favourable and restrictive conditions of ethnographic landscape development. A second step should take into account the calendar time and the historical time. Other two analyses and assessment steps are the heritage value and the artistic perception. The author's geographical, but also ethnographic approach to appraising the ethnographic landscape includes two methods: of synthetic indicators and of the questionnaire, with focus on the former which geographers are more familiar with, namely, the calculation of indicators and indexes, which should be scientifically reliable and suggestive of a dynamic picture of population density, human pressure on the landscape, birth index, and landscape transformation index. The findings helped to the elaboration of a set of assessment maps at national level, each being interpreted and analysed.

The last sub-chapter: *Sustainable development of the ethnographic landscape*, which concludes this study, highlights the protection, conservation, valuation and monitoring of ethnographic landscapes. This sub-chapter follows closely the Ethnographic Landscape Sustainable Development Scheme which involves both management (protection, conservation, valuation and monitoring) and the identification of degradation-induced factors, especially anthropic ones (demographic, economic, political, technological and cultural).

Sustainable development and rural management are one of the most complex topics nowadays, *essentially supposing to strike a balance between conservation of the ecological and social-cultural space and modernisation trends*.

The author himself considers that the analyses he made in this work are not simply a scientific approach, but also a useful research tool. The maps of ethnographic landscape, and their appraisal (Chapter Five) represent efficient means of furthering research into delimiting cultural zones along other ethnographic co-ordinates, as well.

The strong points of this work are: reliable scientific substantiation; discussing issues in the light of the contemporary research problematique by goal-setting and having a methodology directly connected with the subject. A correctly used terminology and a clear, easily understandable scientific language are among the other assets. The graphic illustration, figures, thematic maps and tables match the content perfectly.

In our opinion, it would have been desirable to have the author's own conclusions at the end of this study.

Otherwise, the interesting approach to ethnographic landscape issues, the scientific probity of information, the value and volume of data yielded by field surveys (questionnaires), alongside statistical data, make this volume a valuable scientific contribution, a source of documentation for specialists in the elaboration of efficient protection, conservation, valuation and monitoring measures to preserve the cultural heritage. At the same time, people interested in the positive evolution of the countryside will also find a number of reference points on the subject.

Daniela Nancu