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# DEPTH DISTRIBUTION OF $^{137}\text{Cs}$ IN SOILS FROM SPECIAL NATURE RESERVE BANAT SANDS, SERBIA AND ASSESSMENT OF DOSES TO NON-HUMAN BIOTA

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**Abstract:** A study was carried out to estimate the profile distribution of artificial radionuclide  $^{137}\text{Cs}$  in soils from Special Nature Reserve Banat Sands, Serbia, the largest European sand area, and the dose rates to terrestrial biota resulting from exposure to the Chernobyl-derived radionuclide. The relatively low level of the  $^{137}\text{Cs}$  was detected in soils from the study area. Calculated dose rates were below the screening level of  $10 \mu\text{Gy h}^{-1}$ , indicating no significant risks to the terrestrial biota. Findings presented in this study could serve as a baseline investigation for a subsequent exposure of plants and animals in their natural habitats due to the increasing level of the  $^{137}\text{Cs}$  into the environment as a consequence of possible new release.

**Key words:**  $^{137}\text{Cs}$  · Soil · Depth distribution · Non-human biota · ERICA tool

## 1. Introduction

Artificial, i.e., man-made radionuclide  $^{137}\text{Cs}$  ( $t_{1/2} = 30.17$  years) is one of the essential radionuclides released into the environment as a result of atmospheric nuclear weapons tests and accidents at Chernobyl (1986) and Fukushima Daiichi (2011) nuclear power plants. According to the available data, before the 1986 Chernobyl accident  $^{137}\text{Cs}$  activity concentrations in the Serbian soils were below  $5 \text{ Bq kg}^{-1}$  (Popović and Spasić-Jokić, 2006).

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Following the Chernobyl accident, soils on the territory of Serbia became contaminated with  $^{137}\text{Cs}$ , and its spatial distribution was reported to be influenced by local meteorological conditions and site-specific variables (Dragović et al., 2012b). Results of extensive study show that  $^{137}\text{Cs}$  activity concentrations in surface soils (0-2 cm) collected during 2001 from Vojvodina, northern province of Serbia, varied from 1.1 Bq kg<sup>-1</sup> for Horgoš to 55 Bq kg<sup>-1</sup> for Bavanište (Bikit et al., 2005). The  $^{137}\text{Cs}$  from the Fukushima nuclear accident was not detected in Vojvodina (Bikit et al., 2012). The assessment of radiation doses to human and non-human biota based on soil  $^{137}\text{Cs}$  activities is very important due to long half-life of this radionuclide. Numerous models/approaches have been developed to assess the radiation risk to non-human biota (Beresford et al., 2008; Stark et al., 2015; Vives i Batlle et al., 2007). ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management) Tool software system was applied in a number of studies worldwide to calculate dose rates to non-human biota based on activity concentrations of natural and artificial radionuclides in soils (Černe et al., 2012; Čujić and Dragović, 2018; Oughton et al., 2013; Sotiropoulou et al., 2016; Wood et al., 2008). The assessment of radiation doses to terrestrial non-human biota is of particular importance in Banat Sands (also there is few synonyms currently used in literature: Deliblato Sands or Banat Sandstone), for several reasons: it is the largest continental sand area in Europe; it has been under the protection as a nature reserve since 1977; it is very important natural habitat for numerous species of wild animals, birds (in 1989 was declared an Important Bird Area - IBA (Simić and Puzović, 2008) and plants (in 2005 was declared an Important Plant Area - IPA (Radford and Odé, 2009); and the dune grasslands of this area are used for livestock grazing.

## **2. Materials and methods**

### **Study area**

Banat Sands is located in the southeastern sector of the Pannonian Plain in the southern part of Serbian geographic region Banat (Fig. 1). It extends the length of about 35 km and a maximum width of about 15 km. It covers an area about 300 km<sup>2</sup>, with elliptical shape stretching in southeast-northwest direction. The landscape of Banat Sands is unique among other parts of the Pannonian Plain because altitudes gradually increase from southeast to

northwest but also from southwest to northeast. The dune-deflation relief dominates, as the result of intensive eolian and accumulation processes (Dragović, 2001).

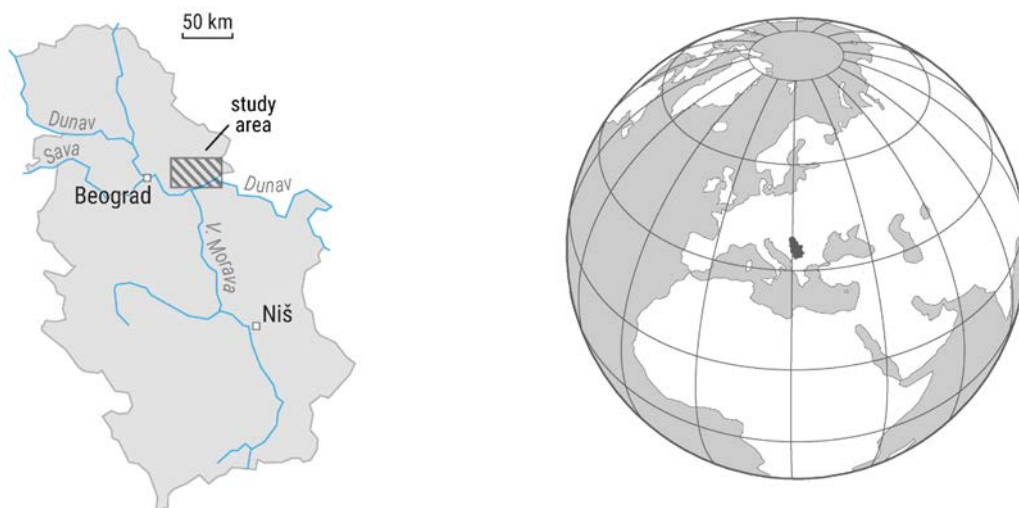


Fig. 1. Banat Sands region within Serbia

The relief of Banat Sands is created by phase action of dominant north-east and south-east winds, by deflation and sand sedimentation (Ivanović, 1975). The major part of the sand-loess complex of Banat Sands is composed of eolian sand sediments, initially formed as alluvial sands that were then blown up by the southeastern wind and accumulated as aero-sediments at the places of the lower wind intensity. The pure eolian sands are of coarse-grained and pulverulent texture, composed mainly from quartz, feldspar, mica, granat, epidote, and iron oxides (Ivanović, 1975). According to Cholnoky (1910) and Milojević (1949), the eolian sands are of Pliocene age. Sandy-loess accumulations spread over the northwestern part of Banat Sands are presented by fine-grained sands, which are accumulated either over eolian ones or lake sands. In this area, there are many loess sinkholes, shallow, oval, and oblong in shape, formed during the processes of dissolution of carbonates from loess and their sedimentation as concretions at the sinkhole bottom. The sandy loess is characterized by the combined intergrain and capillary porosity (Ivanović, 1975). The belts of loess accumulation spread over the western part of Banat

Sands are characterized by intergrain and capillary porosity in their surface horizons (Ivanović, 1975).

The climate of the investigated area is semi-arid continental with elements of steppe climate and belongs to b type according to Köppen climate classification (Köppen, 1936). The winters are cold with low snow precipitation, summers are warm and dry, and autumns are warmer than springs. The mean annual temperature is 10.4 °C, with minimum values by the end of January and the beginning of February and maximum values by the end of July and the beginning of August. The mean annual precipitation is 660 mm, with two maxima, in June and November. According to the values of the Lang rain coefficient (calculated as a ratio between mean annual precipitation and mean annual temperature) of about 60 (with decreasing values towards peripheral areas up to 40), the area belongs to the climate of low forests (Lang, 1920). The southeastern Košava wind significantly influences the climate of the area, blowing from the Carpathian Mountains in the southeast. Soils are represented by a number of varieties of basic soil types. Among undeveloped soils the most abundant is *Albic Arenosol*. Above them the fragments of *Cambisol* and *Eutric Cambisol* occur. They are characterized by low water-holding capacity. For almost two centuries of afforestation, the quicksand is stabilized, and processes of establishment of forest and meadow soils began. Flora of Banat Sands is represented by over 900 species, with some rarities and relicts. Vegetation cover was formed in several phases. Steppe grass and shrub xerophile formations were established as pioneer vegetation, which stabilized the sand and enabled the occurrence of the first stands of dendroflora. The most abundant representatives are acacia and Scotch and black pine. About 97% of forest stands of Banat Sands are formed by afforestation. Fauna of Banat Sands is represented by typical steppe-forest species of insects and wild game.

### **Soil sampling and preparation**

A total of fifteen soil profiles were collected during the period of 2012/2013 from five different locations from the edge of the Banat Sands area (Fig. 1), where dunes with steppe-grassland plains were found. At each location, soil profiles were collected from the dune top, leeward slope, and inter-dune depression (hollow). Soil samples were collected at 5 cm intervals to a depth of 40 cm, obtaining a total of 120 interval samples. All collected soil samples were dried and homogenized mechanically.



## **Analytical methods**

The soil samples in the 0.5 L Marinelli beaker were measured using ORTEC-AMETEK HPGe gamma-ray spectrometer. Obtained gamma-ray spectra were analyzed using Gamma Vision 32 MCA emulation software (ORTEC, 2001). The activity of  $^{137}\text{Cs}$  in the soil samples was determined using its gamma line at 661.6 keV, and the  $^{137}\text{Cs}$  concentration was expressed as activity per unit mass ( $\text{Bq kg}^{-1}$ ). The MBSS2 calibration source in 0.5 L Marinelli beaker (containing a mixture of radionuclides) was used for energy, and efficiency calibration of the HPGe gamma-ray spectrometer and the calibration was checked using IAEA-RGU-1 and IAEA-RGTh-1 reference materials. Soil properties (sand, clay and silt contents, carbonate content, pH(in  $\text{H}_2\text{O}$ ), specific electrical conductivity, organic matter content) were determined using standard methods (ISO 10390, 2005; ISO 10693, 1995; ISO 11265, 1994; Rowell, 1997; Simakov, 1957). The ERICA Assessment Tool (version 1.2.1) was applied in order to calculate external, internal and total dose rates for reference organisms of terrestrial ecosystem available in model (ERICA, 2007). Details on ERICA Tool can be found in different studies (Brown et al., 2008, 2016). The input data consisted of maximal measured activity concentration of  $^{137}\text{Cs}$  in soils in order to ensure that the maximum possible value of dose rates to non-human biota was below the screening dose rate criterion of  $10 \mu\text{Gy h}^{-1}$ . For statistical analysis of data the Statistical Package for Social Science - SPSS 16.0 software package was used (SPSS, 2007).

## **3. Results and discussion**

### **Distribution of $^{137}\text{Cs}$ in soils and its relationship with soil properties**

Results obtained in this study show that  $^{137}\text{Cs}$  was detected in collected soil samples (Table 1), and varied between 0.2 and  $168 \text{ Bq kg}^{-1}$  (mean value:  $15 \text{ Bq kg}^{-1}$ ). Results of extensive study show that  $^{137}\text{Cs}$  activity concentrations in surface soils (0-5 cm) collected during the 2003 from 15 locations in Serbia and Montenegro, varied from  $5.25 \text{ Bq kg}^{-1}$  to  $112 \text{ Bq kg}^{-1}$  (mean value:  $48.3 \text{ Bq kg}^{-1}$ ) (Dragović and Onija, 2006), which is in accordance with values reported in this study.

**Table 1.** Basic descriptive statistics of  $^{137}\text{Cs}$  activity concentrations ( $\text{Bq kg}^{-1}$ ) in the soil profiles.

Depth (cm)	Mean	Std. Deviation	Minimum	Maximum
0-5	46	47	4.9	168
5-10	29	22	4.1	81
10-15	17	17	2.0	59
15-20	12	15	0.2	47
20-25	4.4	4.5	0.3	17
25-30	3.6	3.8	0.3	13
30-35	3.7	4.4	0.3	14
35-40	2.7	3.2	0.3	12
Total	15	24	0.2	168

Depth distributions of the  $^{137}\text{Cs}$  activity concentrations in the soil profiles down to 40 cm are presented in Fig. 2. In soil most of the analyzed soil profiles, the maximum activity concentration was found in the top 0-5 cm layer, and a concentration of  $^{137}\text{Cs}$  decreased with soil depth (see Fig. 2), the shape of the profiles conforms to that expected for an uncultivated site. In soil profiles, 2-c, 3-c, and 5-c collected from the inter-dune depression, the highest  $^{137}\text{Cs}$  concentration was observed at deeper soil layers (see Fig. 2). In all soil profiles collected from location 4, the highest  $^{137}\text{Cs}$  concentration was found in deeper layers (see Fig. 2). Vertical and horizontal migration of  $^{137}\text{Cs}$  in soils and resulting profile distributions are site-specific and depend on number of factors, such as type of soil, land use and soil management practices, soil properties (*e.g.* texture, organic matter content (SOM) and pH), climatic conditions (*e.g.* rainfall, temperature, or humidity), bioturbation etc., physical processes of soil erosion and deposition can be involved in the redistribution of  $^{137}\text{Cs}$  in soils (Al-Masri, 2006; Begy et al., 2017; Gaspar and Navas 2013; Müller-Lemans and van Dorp, 1996; Owens and Walling, 1996; Ramzaev and Barkovsky, 2018; Iurian et al., 2012). According to Kadović et al. (2016) area of Banat (Deliblato) Sands is highly sensitive to degradation, 43.18% of total area belongs to medium sensitivity class, and 56.26% to high sensitivity class. In the recent study about wind erosion conducted in the same study area, based on  $^{137}\text{Cs}$  and  $^{210}\text{Pb}_{\text{ex}}$  measurements, significant erosion rates, especially on the tilled area were found (Krmr et al., 2015). By considering all analyzed soil profiles, most of the  $^{137}\text{Cs}$  (87.7%) was found within the first 20 cm of soils, and a significant decrease of  $^{137}\text{Cs}$  with depth was observed (Fig. 2, Table 1). Below 20 cm soil depth low levels of  $^{137}\text{Cs}$  activity concentrations were found, and  $^{137}\text{Cs}$  showed minimal change with depth (Fig. 2, Table 1). Yan and Shi

(2004) reported different  $^{137}\text{Cs}$  depth profile in dune land, in shift dunes,  $^{137}\text{Cs}$  was distributed throughout the entire sand layer while in fixed dunes  $^{137}\text{Cs}$  decreased sharply below the 15 cm depth.

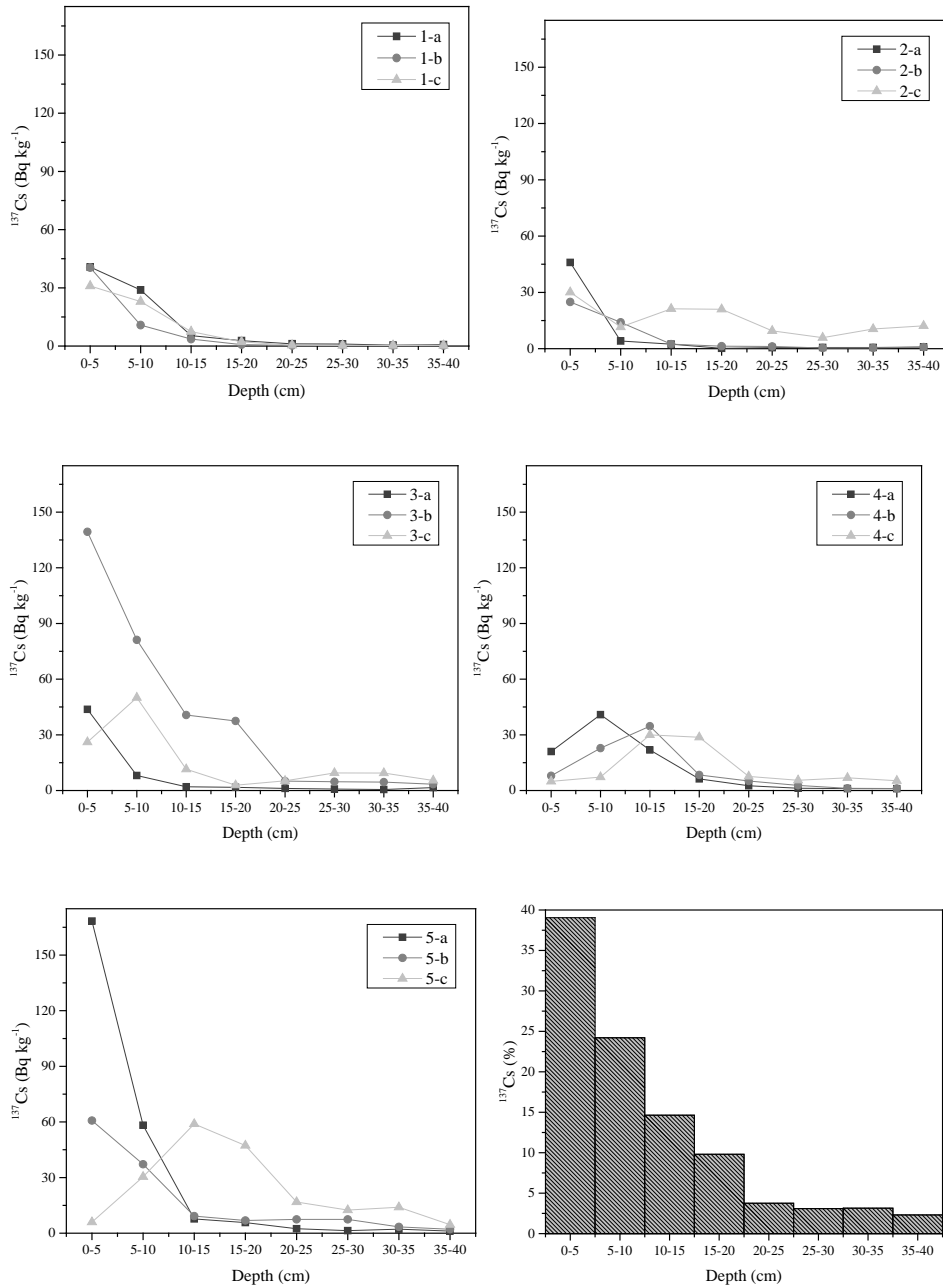


Fig. 2. Depth distribution of  $^{137}\text{Cs}$  in soil profiles

The relations between  $^{137}\text{Cs}$  content in soils and different soil parameters were determined (Table 2).

**Table 2.** Correlation coefficients between  $^{137}\text{Cs}$  and soil properties.

Parameters	$^{137}\text{Cs}$ (Bq kg <sup>-1</sup> )
Coarse sand 2-0.2 mm (%)	0.024
Fine sand 0.2-0.05 mm (%)	-0.196*
Silt 0.05-0.002 mm (%)	0.181*
Clay <0.002 mm (%)	-0.137
Carbonates (%)	-0.156
pH (H <sub>2</sub> O)	-0.483**
Spec. el. cond. (μS cm <sup>-1</sup> )	-0.131
Org. matter (%)	0.422**

\*\* . Correlation is significant at the 0.01 level (2-tailed).

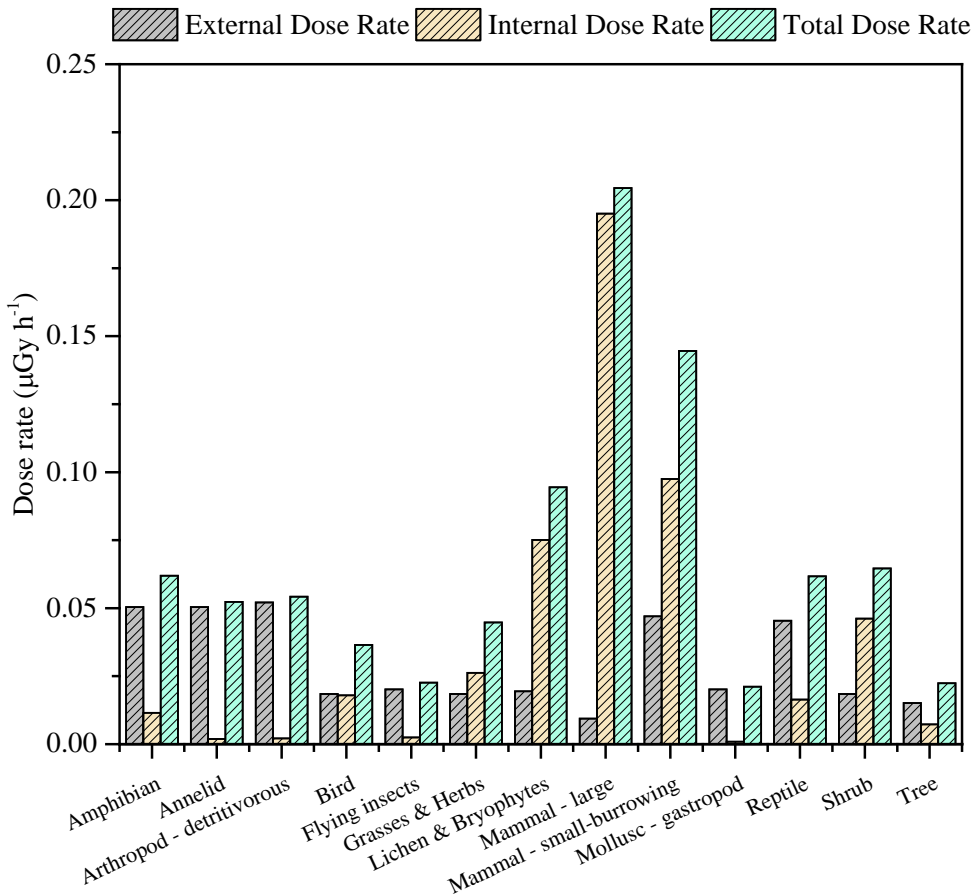
\* . Correlation is significant at the 0.05 level (2-tailed).

The  $^{137}\text{Cs}$  activity concentration was negatively correlated with the fine sand content and positively correlated with silt content (see Table 2) which agrees with the findings of Dragović et al. (2012a). Clay minerals, particularly illites, have a strong affinity for cesium due to its small hydration energy and the presence of frayed edge sites (FES) in the minerals (Dumat et al., 1997; Dumat and Staunton, 1999; Staunton et al., 2002). Nevertheless, no significant correlation was found between  $^{137}\text{Cs}$  values and clay content of analyzed soils (see Table 2). According to results of Gaspar and Navas (2013) and Navas et al. (2011) the lack of significant correlation can be a consequence of homogenous depth distribution of clay in soils and its limited range of variation. A negative correlation was observed between the  $^{137}\text{Cs}$  activity concentration and the pH (see Table 2), which agrees with the findings of Gaspar and Navas (2013) and Iurian et al. (2014). The positive correlation between  $^{137}\text{Cs}$  activity concentration and organic matter content was found (Table 2), which is in accordance with results obtained in several studies (Iurian et al., 2014; Milenkovic et al., 2015; Navas et al., 2011; Petrović et al., 2013). Ritchie and McCarty (2003), Ritchie et al. (2007) and Martinez et al. (2010) found strong and statistically significant correlations between  $^{137}\text{Cs}$  and soil organic carbon (SOC) in agricultural landscapes suggesting that  $^{137}\text{Cs}$  and SOC are moving along similar physical pathways and by the same mechanisms. Iurian et al. (2014) reached similar conclusions, and they found

a strong and statistically significant correlations between  $^{137}\text{Cs}$  and soil organic matter in uncultivated landscapes. In contrast, Martinez et al. (2010) did not find relationship between  $^{137}\text{Cs}$  and SOC in undisturbed landscapes suggesting the impact of biological factors (e.g. biological oxidation, mineralization) on SOC spatial distribution. Different configurations of  $^{137}\text{Cs}$  depth profile reported in study of Iurian et al. (2012) have been attributed to the percolating water, growth conditions of microflora or biotic interactions within the soil.

### Dose rates to terrestrial organisms

The results of external, internal, and total dose rates to terrestrial reference organisms calculated using the ERICA assessment tool are presented in Fig. 3.



**Fig. 3.** Dose rates for terrestrial reference organisms calculated using ERICA Tool

The internal dose rates comparing to external dose rates were found to be higher for following terrestrial reference organisms: grasses and herbs, lichen and bryophytes, large and small burrowing mammal, and shrub (Fig. 3). According to the results of Čujić and Dragović (2018)  $^{137}\text{Cs}$  contributes mostly to the external dose rate. In the present study, the highest total dose rate calculated for a large mammal (Fig. 3) are still much below the value of the screening dose rate of  $10 \mu\text{Gy h}^{-1}$ . The obtained results indicate that terrestrial biota is exposed to low dose rates and that the risk from  $^{137}\text{Cs}$  in the soil is insignificant. Similar dose rates due to  $^{137}\text{Cs}$  in soils were found to terrestrial biota in the area around coal-fired power plant (CFPP) complex "Nikola Tesla" in Serbia (Čujić and Dragović, 2018) and Belgrade area (Petrović et al., 2018). Nevertheless, it is important to stress that despite the low level of dose rates, this study confirms that terrestrial biota has been exposed to  $^{137}\text{Cs}$  of Chernobyl origin. The data obtained in this study can be used as a baseline level for future radiological assessments in the study area.

#### **4. Conclusions**

The results of gamma spectrometry showed that  $^{137}\text{Cs}$  of the Chernobyl origin is still present in soils of the special nature reserve Banat Sands. The vertical distributions of  $^{137}\text{Cs}$  were found to be positively correlated with silt content and organic matter content, and negatively with fine sand content and soil pH. Results of the ERICA Tool show that terrestrial non-human biota is exposed to low dose rates from  $^{137}\text{Cs}$  since all calculated dose rates are much below the value of screening dose rate. The presented results contribute to knowledge about  $^{137}\text{Cs}$  distribution and factors affect its mobility in dune fields, as well as about radiation doses to terrestrial non-human biota in the protected area declared as Important Bird Area and Important Plant Area.

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# SUPPORT VECTOR MACHINES FOR CLASSIFICATION OF SOILS ACCORDING TO GEOGRAPHIC ORIGIN BASED ON THEIR RADIONUCLIDE CONTENT

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**Abstract:** The paper introduces support vector machines (SVM), a recent method in statistical learning theory, used to recognize and classify soils according to their geographic origin. The classification was performed based on activities of seven radionuclides determined by gamma-ray spectrometry. The radionuclides of uranium and thorium series ( $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ ) and  $^{40}\text{K}$  were used to differentiate investigated areas based on geology, while cosmogenic beryllium ( $^7\text{Be}$ ) and anthropogenic  $^{137}\text{Cs}$  were used to differentiate areas according to their susceptibility to fallout. The performances of the proposed method was compared to those of principal component analysis (PCA), linear discriminant analysis (LDA), k-nearest neighbours (kNN), soft independent modelling of class analogy (SIMCA) and artificial neural networks (ANN) applied to the same dataset.

**Key words:** Chemometrics; Lithology; Fallout; Prediction ability

## 1. Introduction

There are a number of well known and widely used methods for analysis of spatially dependent data. Chemometric analysis methods provide powerful tools for the analysis of environmental data which are characterized by strong variation of the element concentration in environmental compartments due to natural inhomogenities and complexity of interactions

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within variables (Einax et al., 1997; Dragović et al., 2007). There are only few studies on employing the chemometric approach in spatial data analysis of radioactively contaminated areas (Kanevski et al., 1996, 1997; Kanevski, 2008; Kanevski et al., 2009).

Support vector machines (SVM) belong to new generation of learning algorithms used for classification and regression tasks (Vapnik, 1995, 1998; Xu et al., 2006). They have been introduced in chemometrics firstly to resolve mid and near infrared classification tasks (Belousov et al., 2002; Devos et al., 2009).

In addition to different classification applications of SVM in a wide variety of environmental sciences, there are a lot of researches based on SVM which are dealing with optimal sample selection in classification (Zomer et al., 2004). For the purpose of estimation of the performance of SVM, many authors have judged this learning theory against artificial neural networks (ANN), very often obtaining opposite results (King et al., 2000, Li et al., 2006). In available literature there are no data on application of SVMs in classification of soils in respect to their radioactivity.

The objective of this study was to test the efficiency of SVM in discrimination of soil samples from Serbia and Montenegro according to geographic origin. Soil samples were analyzed by gamma-ray spectrometry and then classified according to their origin based on their radionuclide content. The specific levels of natural environmental radiation are related to the geological composition of each lithologically separated area, and to the content of natural radionuclides in rocks the soils originate from (UNSCEAR, 2000). Geologically, the territory of Serbia and Montenegro includes a great number of rock complexes (magmatic, sedimentary and metamorphic rocks) which are markedly different in respect to their age, genesis, mineral content and petrochemical and geochemical characteristics. Outstanding differences in natural radioactivity of soils can be connected with their geological origin (Dimitrijević, 1995). Therefore, the set of natural radionuclides ( $^{226}\text{Ra}$ ,  $^{238}\text{U}$ ,  $^{235}\text{U}$ ,  $^{40}\text{K}$  and  $^{232}\text{Th}$ ) was used in this work to differentiate investigated areas based on geology. In addition to natural radionuclides in all soil samples a man-made radionuclide,  $^{137}\text{Cs}$ , derived from Chernobyl accident was also determined, which activity could be influenced by altitudes of sampling areas. Ecosystems at high altitudes are predisposed to receive higher fallout because of high precipitation rates which enhance the likelihood of deposition (Howard et al., 1991). In analyzed soil samples the cosmogenic radionuclide  $^7\text{Be}$  was

also detected. The activities of this radionuclide on the ground are higher in areas of high rainfall. Since the precipitation level is generally higher in upland regions, an increase in concentration of beryllium with altitude is to be expected (Salisbury and Cartwright, 2005). Therefore, radiocesium and beryllium were used in our work to differentiate areas according to their susceptibility to fallout.

## 2. Materials and methods

### 2.1. Samples

A total of 103 samples including six to eight subsamples of surface soils were collected from fifteen geographic regions of Serbia and Montenegro in 2003. The geographic coordinates of sampling locations and the distribution of samples per location is shown in Table 1. After removal of vegetation and other debris samples were dried to constant weight and passed through a 2 mm mesh sieve. Prior to gamma-ray spectrometry measurements, the homogenized samples were stored in 1L Marinelli beakers for one month to ensure equilibrium between  $^{226}\text{Ra}$  and its daughters.

Table 1. Geographic coordinates of locations and number of samples per each location

Sampling location no.	Location	Geographic coordinates (Northing, Easting)	Number of samples
1	Slatina	N 42° 45', E 19° 46'	7
2	Beljanica	N 44° 06', E 21° 42'	6
3	Željevica	N 42° 46', E 19° 46'	6
4	Kopaonik	N 43° 17', E 20° 48'	10
5	Avala	N 44° 41', E 20° 31'	6
6	Devojački Bunar	N 45° 00', E 20° 57'	8
7	Bukulja	N 44° 18', E 20° 31'	8
8	Kosmaj	N 44° 28', E 20° 33'	7
9	Stara Planina	N 43° 24', E 22° 39'	5
10	Surdulica	N 42° 41', E 22° 10'	5
11	Bogićevica	N 42° 36', E 20° 04'	6
12	Durmitor	N 43° 09', E 19° 07'	8
13	Kosovska Kamenica	N 42° 35', E 21° 34'	7
14	Kukavica	N 42° 47', E 21° 56'	5
15	Loznica	N 44° 32', E 19° 14'	9

## 2.2. Radioactivity measurements

Measurements were performed using an HPGe gamma-ray spectrometer ORTEC-AMETEK (model GEM 25) of 34% relative efficiency and 1.65 keV FWHM for  $^{60}\text{Co}$  at 1.33 MeV. All samples were measured for 60 ks. The spectra obtained were processed using Gamma Vision 32 software (ORTEC, 2001).

The  $^{238}\text{U}$  activity was evaluated through gamma ray emission at 63.3 keV (branching 4.8%) of its daughter  $^{234}\text{Th}$ , neglecting the 63.8 keV gamma ray from  $^{232}\text{Th}$ , which has a branching as low as 0.27%. For the determination of  $^{235}\text{U}$  activity the gamma ray line at 143.8 keV was used. The  $^{226}\text{Ra}$  activity was determined through the gamma ray energies at 295.2 and 351.9 keV of  $^{214}\text{Pb}$  and those at 609.3, 1120.3 and 1764.5 keV of  $^{214}\text{Bi}$ . For the measurements of the  $^{232}\text{Th}$  activity, the gamma ray lines at 911.1 and 969.1 keV of  $^{228}\text{Ac}$  were used. The  $^{137}\text{Cs}$ ,  $^{40}\text{K}$  and  $^7\text{Be}$  isotopes were directly measured at 661.7, 1460.8 and 477.6 keV, respectively. Background spectral intensities were determined before sample measurements and subtracted from corresponding sample intensities. For quality assurance purposes checks on calibration were performed using standard reference materials and proficiency test on the determination of gamma emitting radionuclides (IAEA, 2007).

## 2.3. Support vector machines

A SVM represents state-of-the-art learning approach to pattern classification and it is based on *binary classification model* (Vapnik, 1995). Binary model assumes that a soil sample belongs to just one class and that there are only two classes ( $C = \{c_1, c_2\}$ ). Usually  $c_1$  and  $c_2$  are called positive and negative classes respectively. Each classification task with  $n$  classes can be modelled as a sequence of  $\binom{n}{2}$  binary tasks using the *one-versus-one* approach in which one trains  $n*(n-1)/2$  binary classifiers, one for each pair of classes. The final decision is made using voting i.e. a class that is predicted the most is selected as an output. Let  $(\mathbf{x}_i, y_i)$ ,  $\mathbf{x}_i \in R^n$ ,  $y_i \in \{-1, 1\}$ ,  $i = 1, \dots, m$  be the training set. Fig. 1 is used to explain the basic idea of the SVM classification. White and grey squares represent samples from a training set comprised of two distinct classes.

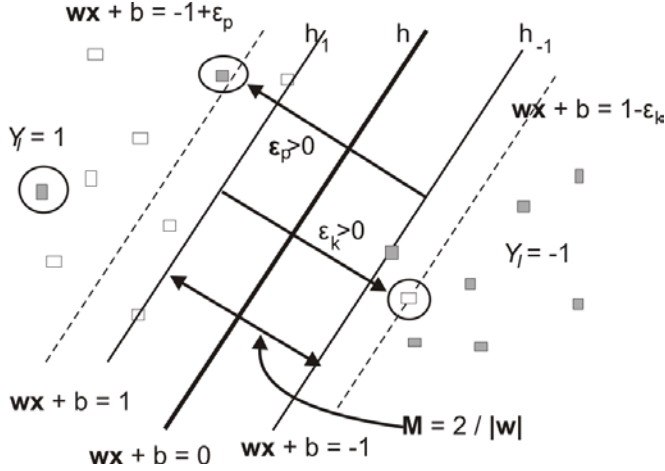


Fig. 1. SVM used for classification: construction of a separation hyper-plane in a two dimensional case (hyper-plane is here a line).

For a moment assume that classes are linearly separable, i.e. neglect circled examples in Fig. 1. During the learning phase one seeks a separating hyper-plane which best separates the examples of two classes. Let  $h_1: \mathbf{w} \cdot \mathbf{x} + b = 1$  (where “.” denotes the dot product) and  $h_{-1}: \mathbf{w} \cdot \mathbf{x} + b = -1$ ,  $\mathbf{w}, \mathbf{x} \in R^n, b \in R$ , are possible hyper-planes so that all white examples lie above  $h_1$  ( $y_i = 1$ ) and all grey examples lie under  $h_{-1}$ . ( $y_i = -1$ ). Hence for all training examples  $(\mathbf{x}_i, y_i)$  it follows that:

$$y_i(\mathbf{w} \cdot \mathbf{x}_i + b) \geq 1, \quad i = 1, 2, \dots, m \quad (1)$$

One chooses  $h: \mathbf{w} \cdot \mathbf{x} + b = 0$  to be the best separating hyper-plane lying in the middle between already-fixed hyper-planes  $h_1$  and  $h_{-1}$ . The notion of the best separation can be formulated to find the maximum margin  $M$  that separates data from both classes. Since the margin is equal to  $\frac{2}{\|\mathbf{w}\|}$ , maximizing the margin is equal to minimizing  $\|\mathbf{w}\|$ . The best separating hyper-plane can now be found by solving the following nonlinear convex programming problem (for solving optimization problem see Fletcher, 1987): find  $\mathbf{w}, b$  to be

$$\begin{aligned} \min_{\mathbf{w}, b} \quad & \frac{1}{2} \|\mathbf{w}\|^2 \\ \text{w.r.t:} \quad & 1 - y_i(\mathbf{w} \cdot \mathbf{x}_i + b) \leq 0, \quad i = 1, 2, \dots, m \end{aligned} \quad (2)$$

In practical classification problems, examples are usually not linearly separable (circled examples from Fig. 2). Therefore, the additional positive slack variables  $\varepsilon_i$  are introduced, which represent the distances of points on the

wrong side of the separating hyper-plane (circled squares). The nonlinear convex program (2) now becomes:

$$\begin{aligned} \min_{\mathbf{w}, b} \quad & \frac{1}{2} \|\mathbf{w}\|^2 + C \sum_i \varepsilon_i \\ \text{w.r.t:} \quad & 1 - \varepsilon_i - y_i (\mathbf{w} \cdot \mathbf{x}_i + b) \leq 0, \\ & -\varepsilon_i \leq 0, \quad i = 1, 2, \dots, m \end{aligned} \quad (3)$$

Parameter C models the penalty for misclassified points in a training set. One wants to find a hyper-plane to minimize misclassification errors while maximizing the margin between the classes. The optimization problem (3) is usually solved in its dual form and the solution is:

$$\mathbf{w}^* = \sum_{i=1}^m \alpha_i y_i \mathbf{x}_i, \quad C \geq \alpha_i \geq 0, \quad i = 1, \dots, m \quad (4)$$

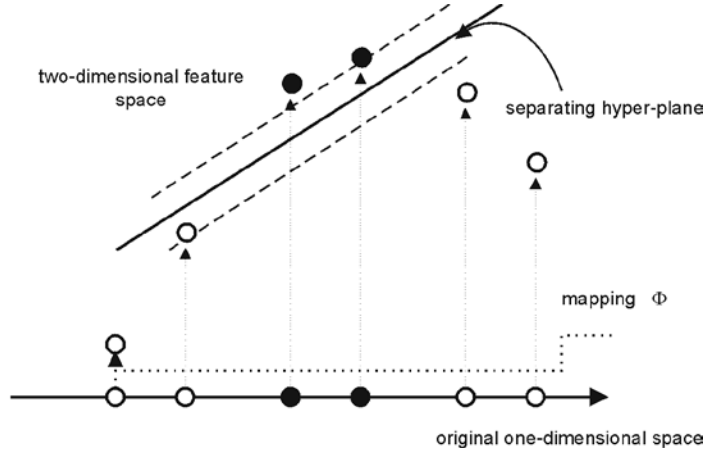


Fig. 2. Mapping examples (here one-dimensional) into high dimensional space (here two-dimensional).

Here a solution  $\mathbf{w}^*$  for an optimal hyper-plane is a linear combination of training examples. However, it can be shown that  $\mathbf{w}^*$  represents a linear combination of those vectors  $\mathbf{x}_i$  (*support vectors*) for which the corresponding  $\alpha_i$  are non-zero values. Support vectors for which  $C > \alpha_i > 0$  holds belong either to  $h_1$  or  $h_{-1}$  (depending on  $y_i$ ). Let  $\mathbf{x}_a$  and  $\mathbf{x}_b$  be two support vectors ( $C > \alpha_a, \alpha_b > 0$ ) for which holds  $y_a = 1$  and  $y_b = -1$ . Now  $b^* = -\frac{1}{2} \mathbf{w}^* \cdot (\mathbf{x}_a + \mathbf{x}_b)$  and finally classification function becomes:

$$f(\mathbf{x}) = \text{sgn} \sum_{i=1}^m \alpha_i y_i (\mathbf{x}_i \cdot \mathbf{x}) + b^* \quad (5)$$



In order to cope with nonlinearity of the classification problem, SVM approach goes one step further. One can define the mapping of examples in a so-called *feature space* of very high dimension:  $\phi: R^n \rightarrow R^d$ ,  $n \ll d$  i.e.  $\mathbf{x} \rightarrow \phi(\mathbf{x})$ . The basic idea of this mapping into high dimensional space is to transform the non-linear case into linear one as illustrated in Fig. 2 and then to use already explained linear algorithm. In such a space dot-product from (5) transforms into  $\phi(\mathbf{x}_i) \cdot \phi(\mathbf{x})$ . It is known that there is a certain class of functions called *kernels* (Burges 1998) for which  $k(\mathbf{x}, \mathbf{y}) = \phi(\mathbf{x}) \cdot \phi(\mathbf{y})$ , which means that they represent dot-products in some high dimensional spaces, but can be easily computed in the input space. Using kernels (5) becomes:

$$f(\mathbf{x}) = \text{sgn} \sum_{i=1}^m \alpha_i y_i k(\mathbf{x}_i, \mathbf{x}) + b^* \quad (6)$$

In all SVM experiments presented in this paper, an open-source package LIBSVM (Chang and Lin, 2001) as a standard implementation for SVM classification and regression algorithms was used. A detailed review of SVM for pattern classification can be found in Burges (1998).

### 3. Results and discussion

The basic statistics of activities of  $^{226}\text{Ra}$ ,  $^{238}\text{U}$ ,  $^{235}\text{U}$ ,  $^{40}\text{K}$ ,  $^{137}\text{Cs}$ ,  $^{232}\text{Th}$  and  $^7\text{Be}$  in analyzed soil samples by sampling locations is presented in Table 2. The range of natural radionuclide concentrations is a consequence of the variety of lithological components in the investigated areas. The highest activities of radionuclides of uranium and thorium series were measured in soil samples belonging to sedimentary formations as well as in soil samples that stem from magmatic rock complexes of silica oversaturated category. Numerous surveys worldwide have shown that the presence of radioactive elements in soils is strongly conditioned by those existing in the parent material, although the percentage of an element can vary in a given rock as a function of the process to which it has been subjected. The influence on the parent material and physicochemical phenomena associated with its weathering on concentrations of natural radionuclides in soil has been demonstrated in survey conducted by Baeza et al. (1995). Activity concentrations of natural radionuclides in Mediterranean soils have found to be lithologically-dependent (Schoorl et al., 2004; Laubenstein and Magaldi,

2008). Navas et al. (2005) have also shown that natural radioactivity of soils is largely controlled by the mineral composition of the parent material.

Table 2. Basic statistics of radionuclide activity concentrations (Bq kg<sup>-1</sup> d.w.) in soils from different sampling locations

Radio-nuclide	Para-meter	Sampling location														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<sup>226</sup> Ra	Mean	17.8	37.8	25.5	25.0	29.8	18.3	38.2	34.0	32.1	37.4	49.2	44.7	23.3	31.6	25.6
	SD	1.55	2.68	1.76	1.16	1.95	2.37	2.43	1.80	1.17	1.47	4.00	2.09	1.31	1.45	1.60
	Min	15.9	34.5	23.4	23.2	27.6	13.6	35.2	31.8	30.8	35.8	45.1	41.5	21.4	29.3	23.3
	Max	19.8	41.9	27.5	26.5	32.7	20.9	41.6	36.9	33.8	38.7	54.9	47.2	24.9	32.7	28.0
<sup>235</sup> U	Mean	0.72	1.49	0.63	1.16	1.45	0.90	1.63	1.47	1.47	1.72	2.45	2.00	1.09	1.41	1.18
	SD	0.04	0.19	0.11	2.10	0.07	0.09	0.14	0.05	0.04	0.07	0.14	0.11	0.05	0.05	0.03
	Min	0.67	1.25	0.51	1.07	1.34	0.80	1.37	1.38	1.42	1.64	2.20	1.84	1.00	1.35	1.14
	Max	0.78	1.82	0.81	1.24	1.54	1.04	1.78	1.54	1.54	1.78	2.61	2.15	1.14	1.49	1.26
<sup>238</sup> U	Mean	16.0	32.8	25.0	22.7	31.1	16.7	37.6	33.3	31.5	37.6	49.8	43.1	21.9	30.7	25.2
	SD	1.15	3.01	1.69	0.06	0.66	0.98	2.62	1.57	1.54	1.10	3.84	2.60	0.92	0.77	1.48
	Min	14.6	30.3	23.2	19.9	30.2	15.6	34.3	30.2	30.0	36.1	43.5	39.5	20.5	29.5	23.4
	Max	17.7	38.4	27.7	27.7	31.8	18.8	41.9	35.3	33.5	38.9	53.4	46.1	23.1	31.4	27.3
<sup>232</sup> Th	Mean	23.5	47.5	32.1	35.9	40.6	21.3	44.6	43.9	36.0	47.5	47.6	77.0	32.6	44.7	37.5
	SD	1.18	4.84	4.80	2.85	2.03	2.03	2.43	1.56	1.64	1.84	1.70	4.24	2.09	2.30	1.67
	Min	22.4	40.3	26.3	30.5	37.1	18.3	41.5	41.4	33.6	45.6	45.3	71.0	30.2	41.1	35.2
	Max	25.0	53.6	37.7	40.1	42.5	24.5	48.9	45.9	38.1	50.6	49.5	83.4	35.5	46.8	40.3
<sup>40</sup> K	Mean	422	520	345	580	686	332	652	710	645	651	882	298	655	755	548
	SD	17.4	43.2	22.8	22.0	25.7	21.6	57.6	16.8	29.7	19.2	25.8	21.4	19.8	31.0	24.6
	Min	392	468	314	550	645	301	537	686	610	629	847	271	633	723	500
	Max	442	578	366	611	710	360	705	728	672	679	919	328	677	791	593
<sup>137</sup> Cs	Mean	30.5	15.7	84.7	25.8	77.8	60.0	101	41.3	5.60	40.3	42.8	61.8	60.2	13.8	43.2
	SD	2.00	2.03	3.87	1.86	1.61	4.82	8.53	1.31	0.29	1.38	2.53	2.96	3.16	0.22	3.07
	Min	27.5	13.2	80.9	23.5	75.1	52.7	89.7	39.8	5.25	38.4	40.6	58.4	55.9	13.5	38.1
	Max	32.8	18.9	91.8	29.5	79.9	64.5	112	43.2	5.88	41.8	46.8	68.4	65.0	14.0	46.8
<sup>7</sup> Be	Mean	2.58	1.69	1.48	1.55	1.09	0.82	2.43	3.68	0.77	0.80	3.06	3.57	0.67	1.44	0.72
	SD	0.37	0.08	0.13	0.17	0.09	0.13	0.17	0.30	0.09	0.06	0.18	0.08	0.09	0.06	0.09
	Min	2.09	1.58	1.32	1.26	0.93	0.56	2.14	3.11	0.67	0.73	2.82	3.46	0.54	1.38	0.61
	Max	3.02	1.78	1.65	1.78	1.20	0.98	2.66	3.94	0.89	0.88	3.29	3.70	0.79	1.50	0.86

The variety of activity concentrations of <sup>137</sup>Cs and <sup>7</sup>Be was also observed in investigated soils depending on altitudes of sampling sites. A significant correlation between the accumulated deposition of man-made radionuclides (<sup>137</sup>Cs, <sup>238</sup>Pu, <sup>239+240</sup>Pu and <sup>241</sup>Am) in soils and altitudes of sampling sites has been reported in studies conducted worldwide (Bunzl and Kracke, 1988; Blagoeva and Zikovskiy, 1995; Legarda et al., 2001; Arapis and Karandinos, 2004). However, factors other than altitude, such as physical, chemical and biological properties of soil, influence the behaviour of any radionuclide in the soil, as well as its migration velocity.

Shapiro-Wilk's test (significance level  $\alpha$  was 0.05) (Shapiro and Wilk, 1965) for normality of activity distribution within each radionuclide was applied prior to any classification and revealed normal distribution of the data.

$$k(\mathbf{x}, \mathbf{y}) = \exp\left(-\frac{\|\mathbf{x} - \mathbf{y}\|^2}{2\sigma^2}\right)$$

For classification purposes Gaussian kernel and linear kernel (no mapping, equation (5)) were used. After removing all training data that are not support vector points and retraining the classifier, the same solution will be obtained. Hence, support vectors represented the examples from the training set that best describe the classes. The ability to distinguish between support vectors and noisy data points enabled SVM to increase its generalization capacity in the learning process.

To test the quality of proposed classification method the *linear accuracy* measure defined as ratio of the number of correctly classified samples to the number of samples in test set was used.

In order to assure numerical stability of SVM classification, algorithm values of all parameters in data set were transformed to be roughly between -2 and 2 by applying the log transformation. A SVM classifier with Gaussian kernel was compared to a classifier with the linear kernel. Kernel parameter *gamma* and penalty *C* were varied from the following values {0.1, 0.5, 1, 2} and {1, 10, 20, 50, 100, 1000} respectively.

Results obtained after applying SVM to radionuclide data set are presented in Table 3. From this table it is evident that the performance of the Gaussian kernel is nearly identical to the linear one. This was a very interesting finding which indicates that the soil data points were linearly separable in the space of seven properties presented by seven radionuclides determined in soil samples. Therefore it was decided to use only linear kernel classifier in the remaining train-test splits (only parameter *C* needed). One can see that the linear SVM perfectly classifies our soil samples into 15 predefined classes – geographical areas.

Table 3. SVM classification performance: in the first two splits both Gaussian and linear kernel SVM were tested

Train-Test split	Gamma	C	Gaussian accuracy (%)	C	Linear accur. (%)
25 – 78	1	10	94.87	100	93.56
35 – 68	0.5	100	97.06	50	97.06
45 – 58				20	98.28
55 – 48				10	100
65 – 38				10	100
75 – 28				10	100
85 – 18				10	100

In Fig. 3 a comparison of prediction abilities of SVM and other pattern recognition methods applied to the same data set is presented. By applying PCA to experimental data, the classification rate of 86% was achieved (Dragović and Onjia, 2006). The application of linear discriminant analysis (LDA) as linear and parametric method, which maximizes the variance between classes and minimizes the variance within the classes, resulted in 82.8% of correctly classified samples (Dragović and Onjia, 2007). When a non-parametric method, k-nearest neighbours (kNN), was applied the classification rate of 88.6% was obtained. The results obtained by soft independent modelling of class analogy (SIMCA) method were very poor compared to those of other methods, giving only 60.0% of correct assignment for samples from test set. A back-propagation ANN classifier, designed by an input layer consisting of the radionuclide activities in the soil samples, a hidden layer and an output layer, composed of regions the samples were collected from, resulted in a classification rate of 92.1%. The prediction ability obtained with SVM was 93.6 to 100% depending on the number of samples in the test set.

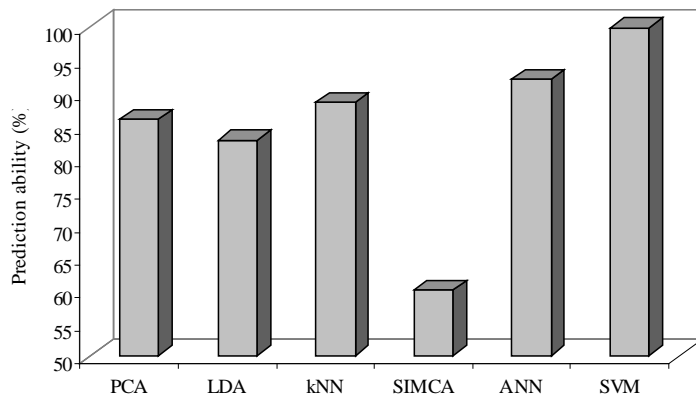


Fig. 3. Prediction ability of SVM in comparison to other pattern recognition methods applied to the same data set

The advantage of the SVM method over the ANN one became obvious in our problem setting: while in the ANN model one must choose between different topologies, a set of initial weights, learning rate, momentum and possibly other parameters, in the SVM approach one needs only one parameter (or two in the case of Gaussian kernel), and yet SVM will always find a global minimum (of error function) if it exists. In the case of ANN, initial random weights usually lead us to local optima.

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# SERBIA AND NORTH ATLANTIC TREATY ORGANIZATION (NATO) – COLLABORATION AND GEOSTRATEGIC PERSPECTIVES

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**Abstract:** According to many public opinion polls, more than two-thirds of the population of Serbia is opposed to Serbia's NATO membership. Serbia proclaimed military neutrality with a parliamentary declaration. The issue of Serbia's accession to NATO is complicated and burdened by several political and geographical factors: attitudes and programs of political organizations that make the majority in the Serbian Parliament, influence of Russia in Serbia, work of the NATO Military Liaison Office in Serbia, maintaining a policy of instability in the Central Balkans, absence of objective consideration of the positive perspectives of Serbia's NATO membership and insufficient activities to promote the social benefits of NATO membership. This paper aims to point out the objective advantages, consequences and disadvantages of Serbia's full membership in NATO, both for Serbia and NATO, as well as the advantages and disadvantages of Serbia-NATO cooperation. This cooperation is already underway within the *Partnership for Peace* program, through the implementation of the *Individual Partnership Action Plan* (IPAP), the *Status of Forces Agreements* (SOFA) and the *NATO Support Procurement Organization* (NSPO). Serbia's security alternatives were also presented, such as eventual membership in the Collective Security Treaty Organization (CSTO) (Russian: *Организация Договора о коллективной безопасности, ОДКБ*).

**Key words:** neutrality, cooperation, partnership for peace, membership, declaration.

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## **Introduction**

Serbia-NATO relations have been burdened by Serbia's dissatisfaction with the way the Kosovo and Metohija issue was resolved after the conflict in 1999. The main outcome of the conflict was the creation of conditions for the forcible separation of the part of the Serbian territory.

The period after NATO's aggression on the Federal Republic of Yugoslavia (FRY) was used by Kosovo, the European Union (EU) and the United States of America (USA) to create the conditions for the creation of an independent state of Kosovo in 2008. By 2012, just over half of the respondents had a negative attitude about Serbia's NATO membership, and that year over 31% of the population said that Serbia's NATO membership would increase Serbia's national security. Russia has been steadfastly opposed to NATO enlargement since the collapse of the Soviet Union, and it has been repeatedly presented to Serbia that such a move in the Kremlin would be interpreted as a security threat to the Russian Federation<sup>1</sup>. Since the change of government in 2012, the number of respondents who have a negative view of Serbia's NATO membership has been steadily increasing. Since then, the influence of the representatives of the Russian Federation on the negative attitude of the government representatives on NATO membership has been growing. There is a link between the strengthening of Russian influence in Serbia and the percentage increase in the expression of a negative public opinion on Serbia's NATO membership.

The rise in popularity of the right-wing conservative parties in Serbia and the recognition of Kosovo as an independent state by almost all NATO members (Spain, Romania, Greece, Cyprus, and Slovakia have not recognized Kosovo's independence due to similar secessionist processes in their countries) significantly contributed to Serbia's alienation from the Atlantic integrations. Although NATO representatives constantly emphasize that Serbia has to decide for itself whether it wants NATO membership, there are no more intense motivational activities by this organization to bring it closer to the membership.

The bombing in 1999 is stated as one of the main reasons for neutrality in Serbia, as well as the distrust towards this organization formed after the massive attack by extreme Albanian civilians and the destruction of medieval

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<sup>1</sup> Milenković, 2012.



monasteries of the Serbian Orthodox Church and Serbian property in March 2004. NATO-led Kosovo International Force KFOR (Kosovo Force), under its authority, has not responded adequately and timely to protecting Serbs in Kosovo and Metohija since 2004, which is one of the major reasons for mistrust and negative public opinion about NATO. NATO's indifferent behavior (KFOR) during the March 2004 events in Serbia was understood as non-verbal and undocumented assent to extreme Albanians for the expulsion of Serbs and destruction of medieval cultural heritage and property of Serbs by the former Kosovo Liberation Army members (KLA) (Serbian: Oslobodilačka vojska Kosova (OVK), Albanian: Ushtria Çlirimtare Kosovës (UÇK)).

### **Serbia's military neutrality**

According to Item 6 of the Resolution of the National Assembly of the Republic of Serbia on the Protection of the Sovereignty, Territorial Integrity and Constitutional Order of the Republic of Serbia of 26 December 2007, Serbia is a militarily neutral state. Military and political neutrality can be temporary and permanent. Temporary neutrality means non-involvement and non-alignment in a specific conflict between two warring parties.

Serbia does not have a recognized neutrality status similar to Switzerland or Austria. From the Congress of Vienna in 1815, through the Hague Convention in 1907, the approval of the Council of the League of Nations in 1920, which recognized Switzerland's neutrality, until the 1955 Moscow Memorandum, which recognized Austria's neutrality, there is a defined path to gaining positions of the constant neutrality recognized by the great powers, military and military-political blocks<sup>2</sup>. Serbia is a part of the Partnership for Peace program, its military forces are participating in NATO exercises, participating in peacekeeping missions around the world and training of security forces within the European Union (EU) military operations. The aforementioned activities are in a collision with the adopted resolution on the policy of military neutrality. It follows that the Serbian army is committed to cooperation with NATO and that neutrality is emphasized when some benefits are to be obtained from the Russian Federation, or in situations where the Government does not have a defined position on a particular geopolitical issue<sup>3</sup>.

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<sup>2</sup> Gaćinović, 2018.

<sup>3</sup>Aktuelne mirovne operacije, 2019.

Military neutrality cannot be enforced and promoted in an isolated manner. It is a part of the state policy, which means that the state also implements political neutrality. Political neutrality should mean that Serbia does not want EU membership either. The dilemma can also be semantic in nature. If Serbia wants to be merely military non-aligned, then the declaration of military neutrality is incorrect from the semantic point of view. In that case, the Assembly should adopt a new document on military non-alignment, because military neutrality is an integral part of political neutrality and Serbia is not a politically neutral state<sup>4</sup>. In many local conflicts, Serbia, through the Ministry of Foreign Affairs, has come to one side (examples of Venezuela, Northern Macedonia, Ukraine, Libya, etc.), thus showing a principled inconsistency on proclaimed neutrality.

Serbia has not been accorded permanent neutrality by international documents or by a decision of the United Nations Assembly as in the case of Turkmenistan, and Serbia cannot, therefore, be considered a neutral state. Serbia does not pursue a policy of neutrality in principle, but neutrality is used as an argument in certain conflicts when the Government does not have a clear position, when assessing the harmfulness, or using it at a given geopolitical moment, or when it comes to the political blackmail of some major power. Neutrality is mainly used as an argument to avoid expressing one's foreign policy position on a particular issue. It is relatively common to hear that NATO respects Serbia's neutrality, but that neutrality is not recognized in any UN, EU, NATO, or other relevant international documents. Thus, Serbia is a sort of detainee of its declaration and is therefore unable to realize many benefits in international relations.

Neutrality is a constant and unchanging principled attitude of non-support to any party, whether conflict within one state, between two states or between state groups and alliances is in question. Neutrality is acquired and confirmed by international reputation, a realization of a national strategy that takes an impartial and neutral stance in conflicting states around the world. This stance should be recognized by international organizations (UN, EU) and countries with high international influence (above all permanent members of

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<sup>4</sup> The unprincipled neutrality is not only a feature of Serbia. The Republic of Austria, the Republic of Ireland, the Republic of Finland, the Republic of Malta and the Kingdom of Sweden are also neutral countries, but they implement the EU policy. Raising the issue of neutrality of these countries before full EU consolidation would have negative reflections on EU stability.

the United Nations Security Council, G7 and G20 members). A neutral attitude can bring many benefits but also long-term damages. The most significant advantage is the freedom to decide and the absence of foreign pressure to support one party in a conflict, contrary to the interests of a neutral state. On the other hand, a neutral attitude makes it difficult to establish friendly and privileged relations with states and alliances.

One of the significant strongholds of military neutrality is the economic self-sustainability of the state. The Serbian economy is highly dependent on international financial institutions and investments coming from the NATO countries. That is why the EU and NATO memberships are often linked as logical, although there are no official documents that condition the EU membership with NATO alliance.

Serbia's Gross Domestic Product (GDP), banking system, and *the UN Human Development Index* (HDI) are significantly behind Switzerland or Austria, making military neutrality difficult to maintain. Serbia also has a demographic problem of depopulation and economic migration abroad, which significantly affects the operational military power. Serbia's refusal to discuss NATO membership can distance the country from the EU through indirect activities, both by the EU institutions and by the governments of high-impact countries (Germany and France). In the process of Serbia's accession to the EU, any member state may raise the issue of Serbia's membership in NATO as an informal condition for accepting the EU membership. In the event of rejection, another request may arise as a formal requirement, such as the border issue, which would be difficult for Serbia to accept and extend its candidate status for a longer period.

### **Serbia-NATO relations since 1999 and NATO ties with the KLA**

Officially, the conflict between Serbia and NATO arose as a result of exceeding the use of force by Serbian police, military reserve and paramilitary forces in Kosovo and Metohija to counter the emergence and development of terrorism. The interventions targeted the dismantling of the KLA units, which in 1996 carried out several bombings on police stations in Kosovo and Metohija and claimed responsibility for the attacks, thereby declaring it a terrorist organization in Serbia. In many countries, during the NATO bombing, the KLA was portrayed as a guerrilla group<sup>5</sup>. The actions taken and carried out

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<sup>5</sup> Kosovo Liberation Army, 2019.

by the KLA had the characteristics of rebel terrorism. In 1997 and 1998, attacks were extended to members of the regular army of the Federal Republic of Yugoslavia (FRY). The actions were funded by the Albanian diaspora, and no security agency, or organization of a similar type, announced the origin of the money. For such actions to gain the approval of the United States of America (USA), the Albanian diaspora has earmarked large sums of money to fund Albanian lobbyists in the US Congress. It is an organization that has portrayed itself as a liberation movement, but which has also been labeled as "the undoubted terrorist organization" by the US Special Envoy for Kosovo and Metohija Robert Gelbard<sup>6</sup>. In the US media, the KLA has often been labeled as a guerrilla group, but it has also appeared on the lists of classic terrorist organizations, whose units have been legalized by a transition into the *Kosovo Security Corps*, and since 2009 as the *Kosovo Security Force*. Milašinović and Putnik (2007) cite semantic dilemmas, differences, and clarifications regarding the meaning of the term "guerrilla" and emphasize that the terms "guerrilla" and "terrorism" should not be identified or linked. Guerrilla movements (Spanish: *guerrilla* - small war) and organizations are fighting to liberate the occupied territories from foreign forces and the object of their struggle are armed forces, while civilian targets and hostages are not their subjects of interest<sup>7</sup>. Most often, terrorist organizations attack police stations and military facilities, as well as facilities where it is estimated to be more civilian casualties. Activation of explosive devices on civilian objects or vehicles with mass fatalities are characteristic of terrorist organizations in Southwest Asia<sup>8</sup>.

NATO was clearly opposed to the secession of Kosovo before and during the bombing of the FRY and shortly after the signing of the Kumanovo Agreement. In NATO's political body, the bombing aimed at preventing a humanitarian refugee crisis from Kosovo and Metohija and repeating a similar situation as in Bosnia and Herzegovina during the 1992-1995 Civil War. Although Kosovo Albanians were made aware that NATO had no intention of forcibly separating part of the FRY and that NATO supports the sovereignty of the FRY, extreme Albanians wanted to use the NATO-Serbia conflict to realize the goal of creating one more Albanian state on the territory of another

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<sup>6</sup> Council on Foreign Relations, 2019.

<sup>7</sup> Milašinović and Putnik, 2007.

<sup>8</sup> On 16 February 2001, an explosive planted under the road in Livadice near Podujevo was activated at the time when a bus convoy of Serb civilians was passing by. At the time, 12 Serbs were killed and 43 were injured. There was no final court ruling for this attack.

sovereign state with a long-term goal of the unification of all territories where the Albanians are the majority into one state. However, NATO, Western European countries and the USA allowed the KLA to engage them in the war against the FRY using their information on the ground before the airstrikes and during the bombing of Serbia, and thus clearly aligned themselves with the extreme Albanians.

It is unclear what was the US interest in entering into a conflict over NATO with a sovereign state that did not directly or indirectly threaten its interests. Expecting NATO strikes in response to inadequate use of force by Serbian security forces, the KLA launched a large wave of refugees from Kosovo and Metohija towards Albania and other Balkan countries. The exodus was shown on all major international information networks and used as an alibi for a more intensive continuation of NATO airstrikes against military and civilian targets in the FRY. At NATO, they were aware that extreme Albanians would use the refugee crisis to gain the sympathy and compassion of Western countries and thus pave the way for the independence war. Taking into account Milošević's aggressive campaign, NATO and Western powers considered it to be the least bad option<sup>9</sup>. As a result of NATO's war against the FRY, in spite of all relevant UN documents and with great support from the USA and the EU, Kosovo declared independence from Serbia in 2008. The world thus began to recognize the independent state of Kosovo, which was declared on the part of the territory of the sovereign state of Serbia (one of the two republics of the FRY). And what failed the Kurds in Southwest Asia succeeded to the Albanians in the Balkans. Separation of the part of the territory of a sovereign state is known in political-geographical theory as secessionism. Even today, in the propaganda of Western media and politicians, Kosovo is considered to be a specific problem and no similar scenario can occur. This attitude has no scientific basis because every territorial-national issue is specific, wherever it occurs. There are many such examples, from Crimea, Northern Cyprus, Catalonia, Palestine to Taiwan, but the United Nations has not been involved in this process. The culmination of geopolitical incorrectness is the demand that Serbia recognizes the independence of the pseudo-state of Kosovo, which was proclaimed in its territory, without its consent.

Since 2006, when Serbia signed a cooperation agreement with NATO and the opening of the NATO Military Liaison Mission in Belgrade, relations

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<sup>9</sup> Allin, 2002.

between Serbia and the North Atlantic Alliance have been steadily improving, both through the Partnership for Peace program and the cooperation in the area of terrestrial security along the administrative borders of Central Serbia and the Autonomous Province of Kosovo and Metohija.

In the development of NATO-Serbia relations, the geopolitical problem of Kosovo and Metohija has begun to be an obstacle to NATO's efforts to win Serbia for the Atlantic integration because of the role NATO has accepted as the protector of the "oppressed" people of Kosovo. Now, this role is becoming an increasing burden each year for the implementation of the geostrategic plans of NATO, but Serbia as well. In the long term, NATO would have a more reliable, organizationally and technically capable and equipped member in Serbia than in any other Central Balkan country. Serbia is significant to NATO because of its geostrategic position, educational resources in the Serbian military, institutions cooperating with the military, scientific institutes and dedicated industries. The history of US-Serbian military relations is much longer and of better quality than that between the USA and Albanians. Serbia-US cooperation has always been at the level of state institutions and has not been funded with the money of dubious origin. On the other hand, Albanian lobbying in the US Congress makes sense to the point where the lobbying club, or the State Department, does not recognize that further representation of Albanian interests is in collision with the US interests. Albanian lobbyists are likely to get suspended in the future due to a lack of funding. Suspending lobbying would force Albanians from Kosovo and Metohija to devote themselves more honestly to negotiations with Serbian representatives in finding a lasting agreement on Kosovo and Metohija.

### **The future of Serbia's relations with Russia and the security alternative**

Russia conducts a wise long-term foreign policy and skillfully uses the intelligence of its security structures. It sees Serbia as one of the points of weakness in the Western civilization circle and builds on this the strategy to deter the most important Central Balkan country from full NATO membership.

Combining demotivation activities, the benefits of supplying natural gas and the sale of military assets at the border of operational use, Russia seeks to maintain the vulnerability of peace in the Balkans. This is evident in the presence in the Balkans, but also in the EU itself, and raises the question of the impact of Russia in declaring British society to leave the EU (*British Exit*,

BREXIT). Between BREXIT and Serbia's prevention to access NATO, there is a logical link and a geostrategic parallel. People's friendship has little to do with these processes and falls within the domain of gaining a psychological advantage by acquiring widespread civic support. Besides, Russia is not in the interest of the EU being too weakened because of the foreign investment from the EU and maintenance of a monopoly on energy sales on the Union market. Russia does not wish the strong US influence on the EU and is, therefore, able to afford the Union a good price for energy and raw materials. It is important for Russia to strengthen its presence in the EU as a depreciation zone for military-political relations with the US.

It is important for Russia and the CSTO that Serbia does not join NATO for several reasons. In its relations with Serbia, it uses mechanisms of threats and privileges. If Serbia applies for NATO membership, the Kremlin's threats are about changing its policy towards Kosovo and suspending its arms modernization treaty. If it remains permanently military neutral or expresses a desire to join the CSTO, Serbia can count on a stable supply of the economy with the required quantities of natural gas and the Kremlin's support in the UN Security Council concerning Kosovo. One of the main reasons is the loss of Russia's geopolitical influence in the world and the cessation of the political-geographical crisis and regional political tensions that allow Russia a high level of geopolitical presence and influence on the world map of neuralgic points. No less significant reason is the trade in geopolitical influence by which Russia may pursue other goals or interests. Under certain circumstances, Russia may agree to recognize Kosovo as an independent state if the USA and the EU accept that Crimea is an integral part of Russia and sanctions are lifted on Russia. In the long run, Russia would benefit from this scenario, Serbia would permanently lose Kosovo and Metohija, and the USA and the EU would pursue the long-term aspiration for Kosovo to become a full UN member.

Due to the non-resentment policy towards Russia, it can be interpreted that Serbia has abandoned the principle of sovereignty over the territory by tacit acceptance of Crimea's violent annexation. The principle of territorial sovereignty does not recognize the inconsistency. If Serbia does not recognize Kosovo because it has been torn from its territorial sovereignty without negotiation, then it should also disapprove any annexation or secession around the world, including the one that happened in Crimea. The history of Crimea is complex and Russia has claimed the right to return this peninsula under its sovereignty because Crimea was part of Russia until 1954 when Nikita

Khrushchev separated and annexed it to Ukraine. In 2014, a referendum was held in Crimea without consulting the Ukrainian authorities, in which more than 97% of citizens voted for secession from Ukraine and annexation to Russia. In this crisis, there was no more serious negotiation between the two countries than there was the negotiation of Albanian representatives in Kosovo and Metohija with the Serbian authorities when the declaration of independence from Serbia was adopted at the Kosovo Assembly. On the other hand, the unprincipledness of Russia is reflected in the non-recognition of Kosovo as an independent state, and itself annexed the part of the territory of Ukraine, without any negotiations with the Government of Ukraine. Referring to historical circumstances does not make much sense because in that case, everyone would refer to the historical periods that benefit them most.

Kosovo has been viewed by the western part of the international community as a special case (Latin: *sui generis*), and that there are no similarities to secessionist aspirations in other parts of the world. This argument does not have a foothold in political geography and international law because the same could be argued for all secessionist processes in the world. Moreover, Kosovo was not a federal unit of a state, but a province or a region, such as Provence. Other processes, the secession, and annexation of Crimea, the attempted secession of Catalonia, the separation of South Sudan, etc., have emerged as a result of Kosovo's recognition. The proclamation of an independent Kosovo is, from a political-geographical point of view, illegitimate because the provinces do not have a constitutional right of separation from their home country. Unlike Kosovo, which declared independence in the Assembly, in Catalonia, the Crimea, and South Sudan, referendums were held, with the overwhelming majority opting for separation from their home country. Despite a successful referendum, Catalonia was denied the right to independence, South Sudan was granted independence, and Crimea's annexation to Russia was not recognized by the EU and the USA.

In order to maintain good relations with Russia, Serbia should make a long-term treaty by defining bilateral perspectives and informing the Kremlin administration that Serbia's interest and intention is NATO membership, with the desire to further improve political, economic and cultural relations with Russia. In agreement with NATO, Serbia could avoid installing missile systems and other offensive weapons that could pose a threat to Russia or Belarus. Given the flexibility proclaimed, NATO would probably agree to such a proposal, but Serbia should make some other, less painful, concessions.



It is well known that every geopolitical move Russia carefully considers, the Kremlin does not take swift action and base its diplomacy on strategic priorities. Therefore, Russia would probably not take more rigid measures against Serbia. With negative reactions and possible penalty proceedings, Russia would lose influence in Serbia and the Balkans in the long run, and great powers are reluctant to hand over complete geopolitical power to other forces.

The European Union and the USA are demanding that Serbia support sanctions on Russia over the Ukrainian crisis, and that request is backed by NATO as well. The Serbian government has stated that it does not want to change its policy towards Russia because it is not yet a full member of the EU, and the obligation to impose sanctions applies only to EU members. This attitude can do more harm than good to Serbia. It should have justified its position by arguing the principle of opposition and non-imposition of sanctions to any country in the world because during the 1990s Serbia itself was exposed to inappropriate, lengthy and rigid sanctions. Due to their role in the war in Bosnia and Herzegovina, the UN Security Council Resolution 757<sup>10</sup> from 30 May 1992 introduced to Serbia and the FRY economic, cultural and sports sanctions, which lasted until 1996<sup>11</sup>. The sanctions were reintroduced in 1998 by the EU and USA decisions for allegedly persecuting Albanians from Kosovo and Metohija and undue use of force in preventing terrorist acts. Interestingly, a dozen resolutions punishing Serbia during the 1990s were unanimously adopted by the United Nations Security Council, meaning that the penalties were also backed by the Russian Federation as well. The sanctions were finally abolished after regime changes in Serbia in 2000, and with interruptions lasted about 6 years. The sanctions have delayed the Serbian economy, the standard of living of the population, scientific and technological and cultural development for decades, but have not achieved the expected goals, but have strengthened the totalitarian rule of extremist forces. The damage from the sanctions was never accurately calculated, and the consequences were immeasurable given that the large state-owned companies, which were the engine of the economy, went bankrupt or under bankruptcy proceedings. Serbia's principled stance against the imposition of sanctions

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<sup>10</sup>United Nations Security Council, 1992.

<sup>11</sup> United Nations Security Council Resolution 757 was adopted on 30 May 1992 on charges that Serbia, through Yugoslav People's Army, placed itself on the Bosnian Serbs side in the war in Bosnia and Herzegovina.

would apply to all countries of the world and should be promoted as a *primum non nocere* (Latin for "do not harm").

### **Cooperation under the Partnership for Peace program**

The Partnership for Peace is a program that involves NATO's bilateral cooperation with individual non-alliance countries and refers to the empowerment of states to maintain peace based on the principles of voluntary transparency of cooperation. Specific cooperation is achieved through the exchange of information in the field of security and participation in international peacekeeping missions and other activities. Serbia has been a participant of the Partnership for Peace program since December 2006, when more mutually beneficial agreements were concluded with NATO. One of the most significant is the *Individual Partnership Action Plan* (IPAP)<sup>12</sup>. This document was also adopted by NATO in 2015 when its implementation began. The agreement allows partners to exchange information, protect classified information, cooperate within the *Science for Peace and Security* program (SPS).

NATO-Serbia cooperation under IPAP is planned and adopted for the periods of three-years. Progress in almost all areas of cooperation has been reported so far. The SOFA agreement was also signed in 2014, which legally regulates the transit and deployment of military forces and effective NATO member states through the territory of Serbia. The 2006 SOFA agreement was signed with the USA, enabling successful cooperation between the Serbian Army and the Ohio National Guard.

The Partnership Individual Action Plan emphasized that Serbia intends to conduct a comprehensive and active information campaign on key defense reform issues and the scope and benefits of Serbia's cooperation with NATO under the Partnership for Peace program. The proclaimed goals related to objectively informing the citizens about the nature of cooperation with NATO in Serbia have been seldom implemented. On the contrary, there is a noticeable campaign by some state officials against the cooperation with NATO and an emphasis on defense cooperation with Russia. As a result of ignoring the agreed plan, there is an increase in the number of opinion polls opposed to Serbia's NATO membership.

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<sup>12</sup> Radosavljević, 2017.

Public opinion on major social issues can be shaped in many ways, depending on the use of information resources that have the power to shape or change opinion in particular educational groups of the population. In the case of Serbia-NATO relations, the political structures opt for two variants: the first, to adapt to public opinion in order to achieve a favorable election result, shaping accordingly its position, and the second, to change public opinion following the political party objectives. Neither of these options is favorable to Serbia's long-term strategy. It is necessary to open a lengthy public expert discussion on the benefits Serbia would gain from NATO membership to objectively consider the possible consequences of that membership. National policy in the field of accession to military and military-political alliances should be harmonized in the framework of strategic documents, which should be designed by scientific institutes, faculties, and departments in this scientific field. The National Assembly should adopt a coherent strategy proposed by the competent institutions, and the executive government should implement this strategy in stages.

National Assembly declarations of military neutrality or membership of an organization reflect the superficiality of governing structures. Not all MPs can be expected to have a comprehensive view of long-term national interests. Often MPs have primary political party interests, and MPs vote per the political party discipline and are often driven by some short-term personal goals and ambitions. The decision of whether a country should be militarily neutral cannot be made by the individual or political structure currently in power since such an approach is characteristic of countries without entrenched democracy. Political parties and coalitions in power should pursue policies that are designed with strategic documents. The only difference is what dynamics and models will be used by the current government when implementing the policy defined in the national strategy papers. The most significant benefits that Serbia would gain from NATO membership are the following:

1. Security of state territory and population from attacks by other countries and organizations (primarily NATO members in Serbia's neighborhood);
2. Reconciliation with the countries Serbia conflicted the 1990s;
3. Protection of the population and institutions from terrorist activities;
4. Standardization and modernization of Serbia's defense system with the assistance of NATO institutions under favorable conditions;
5. Integration of the Defense System into the NATO Defense Structures Network;
6. Possibility of the presence of the Serbian army within KFOR forces;

7. Scientific and technological development in the domain of the defense industry;
8. Security of placement of combat assets on the market of NATO members and other countries;
9. Ability to resolve regional geopolitical misunderstandings within NATO institutions;
10. Guarantees of greater security of foreign capital in the country and significantly higher investments in the economy;
11. More favorable credit rating due to greater security of capital and opportunities related to membership in the World Trade Organization (WTO);
12. Faster and more relaxed EU accession process;
13. Extended and deepened cooperation with other NATO member countries in the field of training and education of the military members in reputable institutions;
14. Possibility to influence the decisions related to Serbia's strategic partners, which cannot be NATO members, within NATO;
15. Scientific and technical cooperation in the civil sector;
16. Harmonization and adoption of new procedures in civil protection;

The disadvantages of Serbia's eventual NATO membership should also be highlighted. The most important are the following:

1. Military-technical cooperation with Russia would have to be reduced;
2. Initially, significant investments would be needed in the modernization and harmonization of weapons, tools, and equipment according to NATO standards;
3. Harmonization of individual decisions in the field of defense with NATO institutions (principle of limited sovereignty that applies to all members);
4. Greater commitments regarding participation in combat operations and peacekeeping missions worldwide.

With a balanced approach and objective consideration of the benefits of Serbia's NATO membership, the perception of public opinion would begin to change. It would then highlight the benefits of Serbia's NATO membership. In a relatively short period, the public opinion of a significant part of the population would also change and the country's reputation would be at a much higher level. Surveys conducted by Ninamedia Research for the Institute of European Affairs in March 2019 showed that 79% of respondents did not support Serbia's NATO membership. The study was conducted on a sample of 1207 subjects. The negative attitude towards membership was mainly caused

by the educational structure and insufficient awareness of the benefits of NATO membership. Out of the total number of respondents, 52% were respondents without any school, with incomplete primary education, or with the second and third level of secondary education. With 4 years of vocational and high school education completed, there were 31% of the respondents, while only 17% of those with higher and faculty education. Interestingly, when asked if they know that Serbia has the highest status of a NATO partner country since 2015 and had 109 joint military exercises with NATO and NATO members in the last 7 years, 57% of the respondents said no<sup>13</sup>. This result indicates insufficient information on current forms of cooperation between Serbia and NATO. The low educational level of the population and the negative attitude of the state administration representatives on Serbia's membership in NATO explains the high percentage of the respondents who say no to the questions raised about Serbia's NATO membership. Despite the currently negative attitude of the public on Serbia's membership of NATO, the administration institutions are obligated to follow the interests of the state, regardless of the public support, or the opinion of certain persons from the state administration. Cooperation under the Partnership for Peace program empowers Serbia to develop regional cooperation and security initiatives through the Centre for Regional Security Cooperation (RACVIAC), whose main tasks are arms control in Southeast Europe, security dialogue and assistance in Euro-Atlantic integration.

## **Discussion**

Prior to the adoption of the Parliamentary Declaration on Serbia's Military Neutrality, there was no scientific analysis of the geopolitical consequences of such a decision. The Declaration of Military Neutrality has, in a sense, affected the indifference of many European countries on the occasion of Kosovo's Declaration of Independence not more than 2 months after its adoption (the Kosovo Assembly declared independence on 17 February 2008). Later, the declaration was used as a variable category in relations with the EU and Russia in order to gain a more favorable position in international relations at a particular geopolitical moment. A policy of loose and volatile military neutrality can bring some short-term benefits to Serbia,

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<sup>13</sup> Institute for European Affairs, 2019.

but because of its unprincipled attitude to significant global geopolitical issues, Serbia risks being labeled a country that does not have its foreign policy principles, since military neutrality is used to pursue short-term national and political party interests.

Public opinion polls on Serbia's NATO membership stratified by education level have shown that the largest number of residents expressing a negative view of Serbia's NATO membership belongs to the lowest education level. On the one hand, there are significantly more citizens of typically unfinished elementary education who have supported the right-wing political parties in Serbia and who have been in power for some time since 2000<sup>14</sup>. On the other hand, few citizens support political options for civic orientation (about 10%). They are mainly distinguished by the higher education and openness of Serbia's membership in NATO. The respondents who support conservative and right-wing options oppose Serbia's NATO membership, citing the bombing of Serbia and the intention not to disrupt relations with Russia and therefore support military neutrality. Attitudes of the population are often influenced by the attitudes of political structures, and often these attitudes are contrary to the state interests. Negative attitudes have been suggested by political organizations and prominent individuals. The government should not pursue state policy based on the public opinion of citizens but implement a state strategy defined based on the long-term interests of the state. Primary and secondary education is predominant in the educational structure of the population and one cannot expect such a majority to think prominently about state interests.

Consistent adherence to the results of public opinion implies that the less educated population generates the position of state representatives about opposition to NATO membership. Decisions that are not multi-layered and geostrategically thought out can produce long-term consequences for the geopolitical interests of the state. On this basis, it can be concluded that neutrality was declared in a hasty, reckless and affective manner.

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<sup>14</sup> From 2000 to March 2003 (until the assassination of the first democratically elected Prime Minister, Zoran Djindjić), the moderate Left was in cohabitation with the right-wing president. From 2003 to 2012, the moderate Right (Democratic Party of Serbia) and the Civic Left (Democratic Party) with the participation of smaller parties took part or rotated in power. Since 2012, the dominant Right has emerged in power, emerging from the wings of a national-chauvinist political organization, which opposes any debate on Serbia's NATO membership and advocates unconditional cooperation with Russia.

Opponents of the Atlantic integration in Serbia often argue for energy dependence on Russia, friendship with Russia, and the same religious affiliation. It is necessary to realistically look at the price of energy imported from Russia by Serbia and to analyze how Russia realizes its interests in Serbia by using the energy dependency position and using the veto in the UN Security Council. Germany also imports gas from Russia, but Russia does not influence German policy, even on the contrary, Germany significantly influences Russian economic policy. Serbia is not as economically strong as Germany, nevertheless, Serbia should pursue its interests and implement long-term geostrategic decisions, instead of subordinating itself to individual great powers. Serbia, on the other hand, receives military aircraft and tools that are at the limit of usability and whose servicing often exceeds the real cost of the asset itself. Information is provided to the public about the value of gifts of military aircrafts, helicopters and other funds received from the Russian Federation in order to give the impression that Serbia has weapons capable of repelling a possible military attack. The operational capability of these military aircrafts is at an unsatisfactory level of usability of the modern army due to obsolescence, costly overhaul, and maintenance, and fuel consumption is significantly higher than that of recent generations of combat aircrafts. Besides, Serbia has a poor experience in conflict with NATO when hundreds of NATO military aircrafts were active during the Alliance's airstrikes during the spring of 1999. The question is whether Serbia could, in a new conflict with a NATO member, provide more resistance with a fleet of up to 15 fighter jets and several helicopters.

Phraseological terms such as "fraternal country", "fraternal people" and the like are often used in Serbia's relations with Russia. The foreign policy of a country should not be based and planned on the phrases and statements of exposed government officials or other public figures. Culturally, historically, and in the way of life, Serbia does not belong to the Eastern civilization circle. The culture and lifestyle of Serbia and Russia are much more different than the Serbian public is aware of. There are not many similarities in the daily life of the population of the Urals, Western Siberia, or the Far East of Russia with the habits of the population of Belgrade, or Šumadia. On the other hand, cultural and lifestyle habits, the consumer lifestyle of the Serbian population is almost indistinguishable from the lifestyles of the peoples of Central and Western Europe. The Orthodox religion cannot be used as an argument for turning from the west and moving closer to Russia. Serbia has been a secular state for

centuries, and the geostrategic orientation of the state does not depend on the attitude of the church. The state addresses the church only on religious issues. All other issues such as integration processes, borders, population policy, etc. should not depend on the opinions of church institutions and the personalities representing the church. Apart from these arguments, it is important to recall that during the 1990s, Russia voted about ten times in the UN Security Council to impose sanctions on Serbia. The arguments of domestic and Russian officials that this was a time when Boris Yeltsin did not want to resent the Western countries were not persuasive, as these were decisions of the Russian Federation. Serbia should not emphasize and criticize past decisions but should take them into account when pursuing its long-term geostrategic interests and aligning its foreign policy with the EU foreign policy.

Serbia's membership to the CSTO, as a security alternative to NATO, would produce certain benefits, but the political, geographical, economic and security consequences would be multiple. By joining this alliance, Serbia could expect more generous weapons assistance, but instead of deterrence, it would, with the great help of the USA, increase its neighborhood armaments activity. Becoming a member of the CSTO would automatically mean suspending the EU membership and probably putting off the power of all NATO projects. By abandoning the EU, Serbia would lose the new investment, face a large decline in living standards, and most current investors from Western Europe would withdraw their capital. Serbia would be in a difficult economic situation again and would lose its patiently built partnerships with Western Europe and the USA. Membership in the CSTO would worsen the political-geographical position, new demands for secessionism would emerge, and the far-right forces in the country would be strengthened because of the Western countries' open support to Kosovo, which would likely be supported in its efforts to unite with Albania, a NATO member state. Due to national differences and geostrategic choices, entity relations in Bosnia and Herzegovina would become even more complex. In this way, the Central Balkans would become a place of great risk of new war conflicts and an area of more intense population outflow. Serbia would probably be suspended without a visa regime, economic emigration would be more intense and more extensive, and in the long run, some sanctions would probably be put in place again.

One of the significant problems of Serbia's national orientation is that there is no general social agreement on the development of a long-term geostrategic plan, which would be implemented by all major political



organizations. Instead, *ad hoc* decisions are made depending on the current geopolitical situation, and often the most significant decisions are made by the leader currently in power.

In addition to the aforementioned arguments on military neutrality related to Russia's neglect and NATO aggression in 1999, the arguments such as large material expenditures for adapting weapons and military equipment to NATO standards, cooperation in NATO bodies with countries which recognized the independence of Kosovo and the like, have been also mentioned. The above arguments are not convincing and can be classified into technical and procedural issues. NATO is helping new members standardize the military system, and it is a process that is going on for decades. The main argument why Serbia should join the NATO Alliance is to improve a distinctly negative political-geographical and military-strategic position.

After Northern Macedonia's NATO membership, Serbia, with Bosnia and Herzegovina (membership depends on the Republika Srpska's stance), will be the only Balkan state not part of the North Atlantic Alliance. Serbia is therefore in a complete environment of this military-political alliance, which carries great uncertainty about its territorial integrity and the risk of a new conflict with the most powerful military organization in the history of the world. A possible conflict or appropriate military response to the attack by some of the lesser NATO members would lead to conflict with the entire alliance. In such circumstances, Serbia is led to believe that it must bear provocations and must not enter into the slightest conflict with the members of the alliance. Russia, though declaring itself a friend and protector, would certainly not enter into a conflict with NATO over Serbia, as its interests are more closely related to NATO member states, and during the 1999 war, Russia stayed on sending verbal support to Serbia and condemning NATO.

If Serbia were a member of NATO, all possible disagreements would be resolved by consensus within the Alliance, both politically and expertly. In economic terms, Serbia is dependent on the EU, whose patron is NATO. EU support to the Serbian economy through investment, trade and industrial development, after decades of wandering, has made the national economy compatible with the EU economies. Any conflict would hinder any development and the rapid decay of the economy would start, as large companies employing tens of thousands of workers would withdraw from Serbia and the economy would stop. It is a misconception that in the event of a crisis, NATO would not attack Serbia because member states have their

companies in Serbia. Multinational companies are rapidly transforming depending on labor and cheap energy, and this argument is likely to be wrong.

When it comes to changing the attitude on military neutrality, the Declaration of Military Neutrality should not be dogmatized. Any new convocation of the National Assembly may repeal a resolution already adopted, or a new resolution can be voted to annul a previously adopted document. The new constitution should define military-political orientations.

Serbia-NATO relations have reached the stage where the two sides need to open new talks on further cooperation. By acquiring a series of geostrategic and geopolitical circumstances, perhaps against its interests, NATO has become the protector of Kosovo. Extreme Albanians from Kosovo manage to abuse and use NATO to achieve their century-old goals, while NATO has no greater use of such activity. The question remains how long NATO will support Kosovo as an independent state and how long it will take for Albanians to fake friendship by pointing out NATO and US flags, although we know that friendship is laden with American suspicion if one knows the relationship of influential individuals from the Albanian national corps towards issues of Islamic extremism. There is still misunderstanding in Serbia regarding the recognition of Kosovo as an independent state by the USA, given that the USA had a very negative experience of secessionism when, in 1861, 11 federal states initiated the process of forming the Confederation, which led to the beginning of the American Civil War.

Based on the experience of the Western countries with Kosovo and the rejection of the recommendations of the Washington administration and the European Commission regarding trade taxes towards Serbia, it can be assumed that the major powers of the West and NATO will require Kosovo to accept the recommendations or relations with Kosovo will be subject to thorough review. Serbia should pursue a consistent, positive and recognizable policy towards NATO, which is the path to stable partnership and membership.

As the first contractual form of cooperation between Serbia and the most important NATO member, the SOFA agreement was signed as a bilateral document between Serbia and the USA, ratified by the National Assembly of the Republic of Serbia in 2006. This document regulates the presence of military structures of a NATO member state on the territory of Serbia, which establishes military cooperation between Serbia and the USA. This agreement was the forerunner of IPAP, adopted by Serbia in 2014. One of the most

significant results is the continuation of successful cooperation between the Ohio Guard and the Serbian Armed Forces (*Serbia-Ohio State Partnership Program*). In addition to the aforementioned agreements, the NSPO (*NATO Support and Procurement Organization*) Agreement was signed and ratified, and the Law on Ratification of the Agreement between the Government of the Republic of Serbia and the NATO Support and Cooperation Organization was adopted<sup>15</sup>. It was not until 2014 that the SOFA agreement with other NATO members was ratified in the National Assembly.

The backbone of Serbia-NATO cooperation is the bilateral relations between Serbia and the USA, which are still burdened by the unresolved issue of Kosovo and Metohija. Good relations between Serbia and the USA are not appropriate for the Kosovo Albanians, because in such a constellation they would lose the status of the 'Balkan victim'. Therefore, Serbia should not give up cooperation and enhancement of bilateral relations with the USA due to the Kosovo crisis or relations with Russia. In the case of conditionality by Russia, Serbia should improve military-political and economic relations with the USA. Only by developing these relationships can the US administration be able to adjust its position on the Kosovo issue. Serbia-US military cooperation confirmed through the alliance in the Balkan wars, both world wars, in joint missions and peacetime.

The end of the second decade and the beginning of the third decade of the 21st century is the period when Serbia should make a historically significant decision on NATO membership. A positive decision to join NATO would finally place the country in a modern and economically prosperous part of the world.

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<sup>15</sup> National Assembly of the Republic of Serbia, 2016.

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# NEW APPROACH TO TOURISM VALORIZATION AND ZONING OF STARI VLAH AND RAŠKA REGION, SERBIA

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**Abstract:** The worldwide tourist regionalization has been growing due to the increasing demand for valorization of tourist potentials. Stari Vlah and Raška form a spatial-functional category with natural and cultural potentials that provide this region with tourist-geographical values of certain taxonomic rank. The values of cultural-historical heritage are increasingly important for contemporary tourism, leading to development of special kinds of tourism including cultural, city/urban tourism, event tourism and religious tourism.

It is possible to form a more comprehensive view of the touristic values and potentials of this region through use of Geographical Information Systems (GIS), helped by techniques such as kriging, cluster and proportionate buffer. The collected raw data were divided into categories according to qualitative and quantitative features and graded on scale 1-5. After a complete GIS numeric analysis was performed, the grades were summed and algorithm was implemented creating clusters and fields in maps. The three main zones of analysis in qualitative sense include: the conditionally developed tourism zone (maximum value), developing tourism zone (medium value) and potential tourism zone (minimal value). The results of detailed GIS geostatistical analysis of Stari Vlah and Raška region have shown presence of new areas of potential tourism and of areas showing constant tourist activity. The natural and social (anthropogenic) tourist values confirmed by new methods were included in the analysis. In this way it was possible to achieve a better approach to this insufficiently explored region in tourist sense.

**Key words:** geostatistics; kriging; cluster; proportionate buffer; zone; tourism potentials

## 1. Introduction

The area of Stari Vlah is situated in the southwest of Serbia, north of river Lim and east of river Drina. To the west Stari Vlah forms a boundary with Bosnia and Herzegovina, to the south with Raška region, to the east with Šumadija and to the north with Kolubara region. It includes parts of three administrative districts with different levels of tourism development: Zlatibor, Moravica and Zlatar. The touristic-geographical region Stari Vlah includes mountains and upland plateau so the main activity of the community is livestock husbandry. This region is very rich in water resources. In the Stari Vlah region rural tourism is experiencing dynamic development. Zlatibor and Zlatar massifs divide this region into three parts: Zlatibor's Stari Vlah (Mt. Zlatibor and city of Užice), Moravica's Stari Vlah (the Moravica river) and Zlatar's Stari Vlah (Zlatar mountain). To the south it reaches the Raška region.

In the stricter sense, the term Raška pertains to the Middle Ibar river basin and basins of left and right tributaries of Raška and Studenica. In a wider sense, the term of Raška is used for the whole area of southwest Serbia, which in the Middle Ages belonged to Raška State. One part of former Raška state in Serbian territory is nowadays known as Raška region. The other part of historical Raška belongs to Montenegro (Lukić et al., 2007). The functions of tourist regions may be homogenous (tourism as basic activity) and heterogeneous (tourism as a complement to other activities). According to motive physiognomy, touristic regions may be: natural, anthropogenic and complex. Physical and geographical characteristics of the region are the base of the natural touristic regions. With their diversity, values and conserved ecosystems these characteristics make tourists move around and do various activities. Anthropogenic touristic regions are based on cultural-historical heritage and different types of events. Monumental heritage of the region is said to be the resource with the highest level of tourist attractiveness so it is logical to always include them in the itinerary. The complex tourist regions contain both natural and anthropogenic values of the region. They provide an opportunity of combining both into a complex tourist offer of a certain region (Golubović and Kicošev, 2004). Considering the level of tourist development of the region it is possible to distinguish a developed tourism zone, developing tourism zone and potential tourism zone.

The combined typology used in this paper was complex and based on the level of tourist development. Methodology of allocation of tourist regions

was based on tourist valorization of natural and anthropogenic elements of Stari Vlah and Raška region. The first step included analysis and valorization of all natural and anthropogenic potentials present in this region. After the valorization of each individual natural and anthropogenic element, three zones were distinguished according to evaluation of present condition of tourist development and its perspectives.

GIS program was used to process all the entered values in order to prepare a final, synthetic map of tourism zones of Stari Vlah and Raška. Base forming for use of geographical information systems is very complex and may be performed in numerous ways. The methodology of this work was based on the starting hypothesis that discussed criteria are relevant for distinguishing tourist regions. However, the distinctiveness of tourist regions was insufficiently studied, and there was no unique tourism analysis that could provide absolutely precise results. The most common form of typology applied in distinguishing tourist regions was the one that divides tourist values according to motive physiology and level of development. Rural tourism in Serbia, as a concept of developing the insufficiently developed areas, was studied in order to show all the existing variations in tourism development. This thematic research has shown daily, monthly and annual variations in overnight tourist stays in Serbia (Todorović and Bjeljac, 2009).

Rural tourism development in Serbia is increasing in significance, particularly in cases when that development is also influencing the overall regional development. Rural tourism as a base for development of villages, especially in previously unexploited regions, may be the central issue in determining a more stable and constant budget, especially in insufficiently developed municipalities. One of the most important things regarding the tourism development, and especially rural tourism, is certainly food and cuisine. Food may be traditional and special, and in some areas allows for significant exporting capacities (Stojanović et al., 2010). Regardless of whether old or new methods in valorization of tourist development were being used, there are certain paradigms and defects in significance of rural contemporary tourism. One of the biggest objections is failure to revitalize the village while performing the activities on tourism development (Medojević et al., 2011).

The overall development of the Republic of Serbia will certainly depend on investments in new areas where it is possible to develop all tourism types. Many challenges and unexplored potentials are to be met on this path

but new techniques will inevitably lead to faster perceiving of the facts (Maksimović et al., 2015; Erdeji et al., 2013). Some of the new methods used in tourism are connected to GIS as well as technologies close to GIS. GPS (Global position system) together with GIS tools successfully calculates the proportion of time each tourist spends in touristic centers. In this way the clusters of big tourist activity were abstracted. GIS methodology determined the clusters showing tourists' needs, movements and habits. In this research, both the spatial-temporal component of each individual tourist's movement and his/her habits were determined. One completely processed destination was Hong Kong (Grinberger et al., 2014). Sustainable tourism development and its use are one of the leading areas in today's geographical science. Analyzing sustainable tourism development resulted in conclusions on each tourist's relation in geospatial matrix (Boers and Cottrrell, 2007). GIS methods such as cluster and kriging connected to geospatial matrix of our country are increasingly used. These analyses are used particularly often on micro- and regional scale. Modern GIS methods are used in insufficiently explored spa regions in Serbia in order to achieve absolute level of marking both natural and anthropogenic tourist attractions. Geostatistical analysis of Lukovska Spa provided the results that may be used for directing the regional development (Valjarević et al., 2017).

Methods such as cluster and kriging were used together in order to determine the tourist and regional values of thermo-mineral resources in Serbia. This method simultaneously provided validation of the actual capacities of spa complexes in explored regions (Ristić et al., 2019; Valjarević et al., 2018). In addition to the usual methods such as cluster and buffer, kriging is also providing good results of geospatial analysis. Unlike the rest of standard geostatistical methods, this method summarizes the data inside the nucleus according to rules of Cornell's nucleus. Therefore the mistakes are minimized. The advantage of this method is that it can be used in almost any GIS software (Hrnjak et al., 2014). In addition to cluster and GIS analysis, buffer analysis is also applied as it provides very precise geospatial analysis. These analyses may be applied in maps for all three types of objects regardless whether they are clustered, linear or evenly distributed. This method was used on the coast of North Carolina to determine the coast tourist potential (Hiang, 1996), while double or parallel buffer was used in a similar study in the city of Hong Kong. This buffer allowed measurement of the value of traffic accidents and the locations where they happened. The results processed by the buffer spanned



the period of 11 years (1993-2004) and have shown the historical changes of the geospatial matrix. In such a way, buffer is applied as a special method in advanced GIS studies of the geospatial matrix (Loo, 2006).

## **2. Materials and methods**

The basic method of valorization of Stari Vlah and Raška was qualitative-quantitative, and it is shown in descriptive and numeric units. Evaluation was performed both for individual elements and for the whole. The complete valorization refers to natural (relief, climate, water, flora and fauna) and anthropogenic elements (settlements and cultural and historical monuments etc.).

The most important values of potential recorded in this study are presented in charts for each evaluated element, also including the grade/rank, its short description and significance. In addition to this chart review there is also the description of tourist motives, abstracted types of tourism which can be developed regarding the given element, as well as analysis and locations of important tourist centers and hotspots. This complete valorization was accompanied by partial valorization of certain elements. Mountains have special values from the geomorphological perspective. In order to achieve as objective valorization of mountains as touristic values as possible, it was necessary to consider the position, genetic type of the mountain, the size of the mountain, horizontal and vertical ruggedness and attractiveness. Among the hydrographic potentials of the rivers, those most important for valorization included: water quality, the length of river, the flow, esthetic characteristics and potentials for tourist development. Partial valorization was performed on settlements and monuments. Urban settlements were particularly valued in this study. The criteria were: position, artistic value, cultural-historical significance, tourist attractiveness, organization and equipping of the space as well as complementarity. The most important parts of monumental heritage of Stari Vlah and Raška are sacral objects so the study included partial valorization of the most important monasteries in this region. Their tourist and geographical position, artistic and ambient values, attractiveness and complementarity were valued. The grades are numeric (with description of their values) on 1-5 scale as presented in Table 1.

Table 1. Econometric analysis of tourist geospatial matrix of Stari Vlah and Raška

Description	Grade
Potentials for tourism development; only a single tourism element which is not included in tourism offer	1
Tourism potentials include at least two tourism elements which may contribute to tourism affirmation	2
Tourism potentials with more isolated elements of tourism valorization of local character	3
Tourism potentials where there are several elements of valorization and there is a realistic possibility of connecting them into a tourism unit of regional importance	4
Tourism potentials whose elements, as an unique tourism unit, may contribute to tourism affirmation of a broader region	5

The last step in this valorization process included abstraction of zones on the map of the studied region. According to valorization of tourist potentials and the existing condition of tourism development, three zones were recognized after valorization of each natural or anthropogenic element: the developed tourism zone, the developing tourism zone, and the zone of potential development. The developed tourism zone contains parts of Stari Vlah and Raška. Its value was valorized by grade 5, meaning that its potentials may contribute to tourist affirmation of a broader region. Parts of observed area valorized by grades 4 and 3 are included in the developing tourism zone. In this case there is a possibility of local and regional development of tourism. Zone of potential tourism includes the areas valorized by grades 2 and 1, which are parts of Stari Vlah and Raška, respectively, where elements were valorized as having insufficient quality to be included in tourist offer. By grouping all tourist elements (natural and anthropogenic) and the abstracted zone for each element, synthetic maps of tourist zones of Stari Vlah and Raška were constructed by use of GIS method. Data processing was performed in several phases and using different methods.

In the very first phase, grades were assigned to the zones according to their level of tourist development. Developed tourism zones were given the grade of 10 and developing tourism zones the grade 5, while the zones of potential for tourism development were valued by assigning grade 3. The second phase covered the summing (overlapping) the maps with the given values. In the third phase, the function of abstracting the certain zones is presented. The total range of summarized values was obtained and divided into three ranks. Territories which had the total range of 5-15 points were included in zone of potential development. Territories with the total range from 15 to 25 were in the zone of developing tourism, and territories with the total range of

more than 25 points in the developed tourism zone (the maximum range was 50 points). Natural and anthropogenic features were presented and valued individually through use of the cartographic method. The synthesis map was obtained by interpolation of all maps based on the current state of tourism development. This very last step had a great importance, as it provided a good methodological basis for the allocation of tourist regions (Kićović, 2016).

## 2.1. Data modelling by implementation of GIS

GIS and data modeling is a way of calculating the tourist values of a particular geospatial matrix with a high degree of reliability. In this work we used two types of GIS software, SAGA and QGIS. Tourist evaluation of the explored space was obtained through use of the kriging, poly-kriging, buffer and cluster methods. The methods were applied together and yielded satisfactory results. For precise calculation it was necessary to use the econometric data from the previous analysis. In the first map (Fig. 1), kriging analysis was performed and carried out through the QGIS software. The special algorithm contained in this software includes the autocorrelation of the measured values within the geospatial matrix. The advantage of this algorithm is that the weight values of the points are not only based on the distance between them, but the errors in positioning the points are significantly minimized (Valjarević et al., 2018). Satisfactory results were obtained in combination of all three types, kriging, buffer and cluster analysis (Fig. 1 & 2).

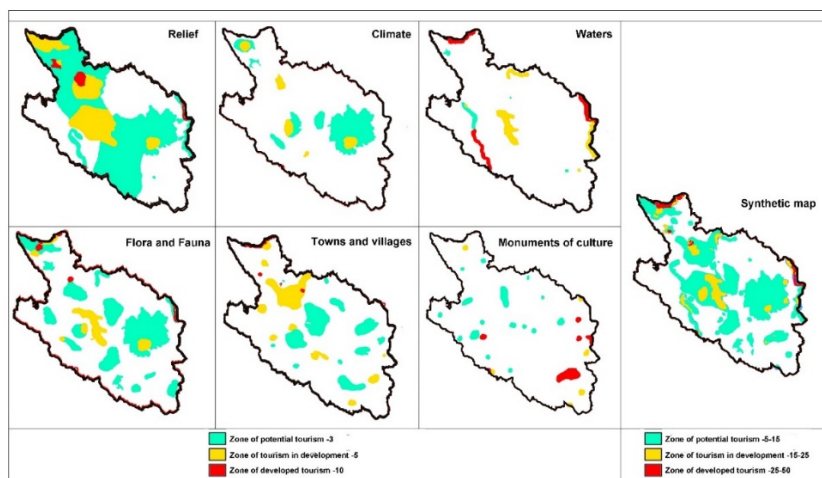


Fig. 1. Synthetic map of the region of Stari Vlah and Raška after the completed GIS analysis. The seventh map was synthesized by using the previous six steps (algorithm).

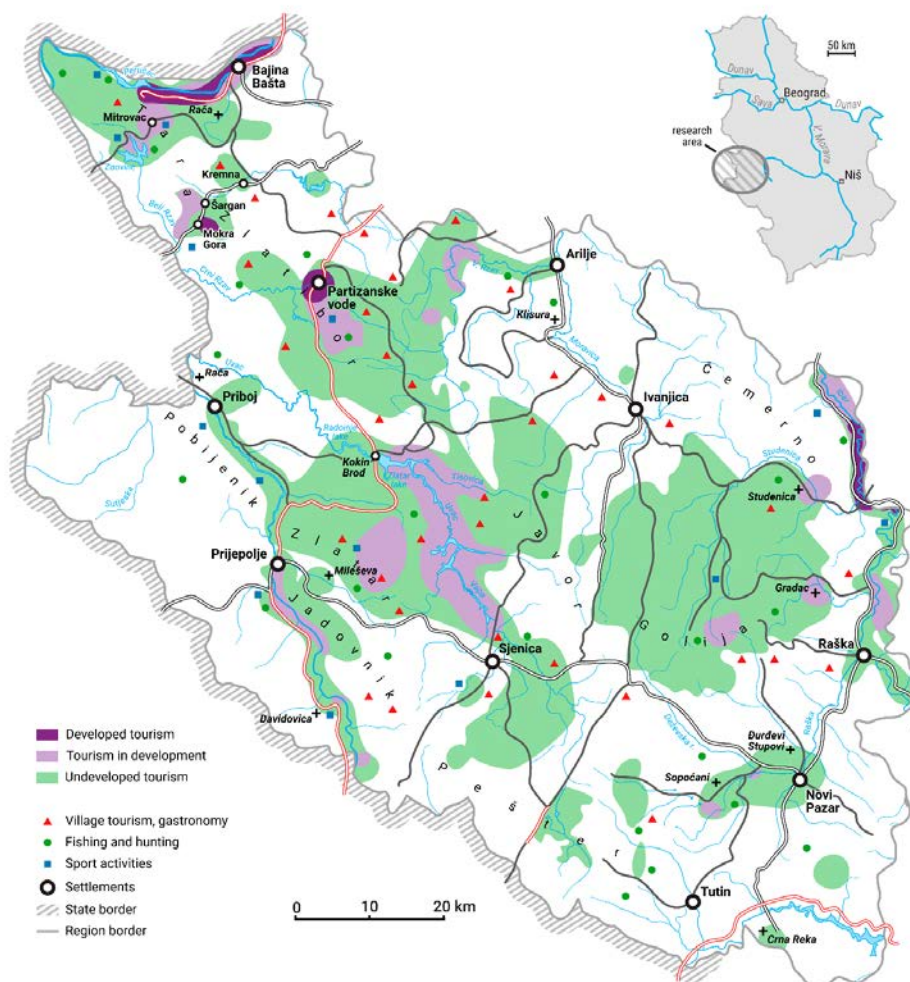


Fig. 2. Geographical map of Stari Vlah and Raška with prominent surfaces, 3 values of tourism development (developed zone, developing tourism and undeveloped tourism zone).

### 3. Results

The analysis of the synthetic map enabled us to distinguish tourist micro-regions with different zones according to level of development. In the area of Stari Vlah and Raška, the following tourist micro-regions are distinguished: Tara-Mokra gora, Zlatibor, Zlatar-Uvac-Lim, Golija-Javor, Sjenica-Pešter and Ibar.

Kriging and buffer analysis have shown the percentages and indicated locations with new and old areas of tourism. The results show that the Tara-Mokra gora tourist micro-region covers the highest mountain parts of Tara, the

Drina canyon, Lake Perućac and Mokra gora. It is one of the most affirmative parts of the Stari Vlah and Raška. The development of tourism in this region is mainly based on natural values. In addition to the level of tourism development, in this region there is a zone of developed tourism that covers the area of the central part of the mountain Tara and part of the Drina canyon, as well as Mokra gora. In this zone there is a tourist center of the region - Mitrovac. The developing tourism zone includes part of the Perućac Lake to Bajina Bašta and around the Lake of Zaovine. Mokra gora is characterized by a diverse natural environment of Mokra gora and Šargan and anthropogenic values such as the "eight", the Rača monastery, the Iver and Drvengrad ski resorts. The central part, around Drvengrad, is located in the developed tourism zone. Developing tourism zone covers parts around the Iver ski resort, and the potential tourism zone spreads west towards Kremna and the isolated Rača monastery. The largest part of the region is in the zone of potential tourism development. The following tourist sites have been selected in this region: Kaluđerske bare, Predov krst, Perućac, Zaovin lake, Beli Rzav canyon, Spajić lake and Hajdučka česma, Mavavnik (Drvengrad) Kremna, Šargan, Iver, Rača. Analyzing the map of the perspective of tourist zones, it may be concluded that the largest part belongs to the zone of the most favorable conditions for tourism development. The southeastern part is located in the zone of favorable, and the furthest eastern parts of the region in the zone of conditionally favorable conditions for development of tourism.

The Zlatibor tourist micro-region is the most developed and well-known region of the Stari Vlah and Raška. The most attractive part of this region is the center of the mountain, Partizanske vode. This area, with significant infrastructure, belongs to the developed tourism zone. It is certainly the most developed tourist part of the territory of the Stari Vlah and Raška, but also among the best-developed ones in the territory of the Republic of Serbia. The natural features represented by geomorphological, climatological and biogeographical characteristics contributed to this region being the leader in the development of tourism (Dragovic et al., 2009). Rural and ethno tourism has been well-developed in this region. The developing tourism zone is expanding around the developed tourism zone towards the south and southeast. The largest area of this region covers the zone of potential tourism development. The tourist center is, of course, Partizanske vode. There were a large number of recorded localities, as almost every Zlatibor village has a potential to be interesting and represent a tourist site. Significant tourist sites

of this region are: Sirogojno, Tornik, Čigota, Čajetina, Mačkat, Stopića cave, Potpećka cave, Ribnica, Zmajevac. It is to be expected that, in the perspective of tourism development, this region will be even more valued. On the map of the perspective of the tourist regions of Stari Vlah and Raška, the zone of the most favorable conditions for the development of tourism is noticeably dominant, which indicates that potentials are numerous and should be used in the right way. The future economic development should be directed so that the main activity of the population would be tourism. In this way this region would be classified within a group of homogeneous tourist regions and tourism would be the leading force of the overall economic development.

Zlatar-Uvac-Lim tourist micro-region has a great potential, but the level of tourism development is not at the level it should be regarding the total value of the whole region. In this region, the mentioned methodology has not identified any developed tourist zone. The developing zone covers the highest mountain peaks of Zlatar and the Uvac gorge and the Lim valley. The zone of potential tourism is surrounding the developing tourism zone. In this zone there are several churches and monasteries, several households that develop rural tourism and hunting areas. The tourist center of the region is Nova Varoš, and the localities: Zlatar, Sjenica and Radoinjsko lakes, the Uvac gorge (the Griffon Vulture habitat), the highest peaks of Zlatar, the Ušac cave system, Aljinovići, Akmačići, Božetići, Štitkovo, Dubnica, Kumanica, Tičje polje, Mileševa, Mileševa canyon, Sopotnica, Hisardžik, Ibrahim-paša mosque, Priboj spa, Kamena gora, Uvac monastery. The perspective map shows particularly high tourist potential, where it is clearly seen that the whole region belongs to the zone of the most favorable conditions for development of tourism.

The Golija-Javor micro-region covers the area of Golija and Javor Mountains, as well as the valleys of the Golija's rivers Moravica and Rzav. In this region there are mostly some concentrated natural tourist potentials (mountainous areas, protected areas, spring Studenica) in addition to two very important sacral tourist objects (monasteries Studenica and Gradac). There are two tourist zones in this mountain region. The developing tourism zone covers the area around the spring Studenica (with a more intensive construction of the accompanying tourist facilities in recent years) as well as the isolated locations of Studenica and Gradac monasteries. The rest of the region is located in the zone of potential tourism development which includes almost the entire mountain of Golija. The tourist center of this region is the village of Devici.

Important tourist sites include: Rudno, Studenica, Gradac, Dajić Lake, Visoka, Panjice Canyon, the city beach in Arilje, Raščici, Prilike, Katići, Kalipolje, Jankov kamen. Considering the potential of tourism development, it is to be expected that in this perspective this region will be a developed tourist region, as presented on the map of the perspectives of tourist regions.

The Sjenica-Pešter micro-region covers the Sjenica basin and the Pešter plateau. Tourism is insufficiently present, as only a small area is in the zone of potential tourism development. Developed and developing tourism zones are not represented in this region. The winter and sports center Žari with its surroundings has great potential, so on the perspective map it is located in the zone of the most favorable conditions for tourism development, which includes the area around the site of Duga Poljana. The central part is around the Vapa canyon. The largest part of the Pešter plateau is in the zone of favorable conditions, while the rest of the region is located in the zone of conditionally favorable conditions for the development of tourism. The tourist center of this region is Sjenica. The most important localities are: Žari, Vapa springhead, Karajokića wells, Duga poljana, Čedovo, Štavalj. The development of this tourist region should be based on a combination of natural and anthropogenic tourist values (rural tourism, healthy food).

The Ibar tourist micro-region covers the valleys of the river Ibar and the city of Novi Pazar. It is distinguished as a tourist region with emphasized anthropogenic tourist potentials. The development of the region is also oriented toward water activities. The largest part of the region is in the zone of potential tourism development, while monasteries Sopoćani and Pazarišta are in the developing tourism zone which also includes the Ibar valley from Ušće to Maglič and the area around Baljevac. The tourist center of this region is Novi Pazar. The most important sites include: Monastery Đurđevi stupovi, Monastery Sopoćani, Altun Alem mosque, Stari Ras, Monastery Crna Reka, Deževa, Jeleč, Novi Pazar's spa, Raška spring, Stara Pavlica, Nova Pavlica, Končul, Brvenik, Maglič, Ušće, the Ibar gorge (valley of lilac). Selected sites show that the development of this region should be based on anthropogenic potential, primarily monasteries and other cultural monuments. The future development of tourism trends rests on these elements, which will be primarily directed toward religious tourism. The map of the perspective of tourist regions shows that the area around Sopoćani and Stari Ras is in the zone of the most favorable conditions for development of tourism. The surroundings of the city of Novi Pazar, with the largest number of monasteries, churches, mosques and

other cultural monuments, are located in the zone of favorable conditions. The rest of the region has conditionally favorable conditions for the development of tourism.

#### **4. Conclusion**

Each tourist micro-region of the Stari Vlah and Raška is distinguished by some specificity recognizable in the tourist market. Some of them are distinguished primarily by natural values, while others have more affirmative anthropogenic values. Some parts of the tourist regions of the Stari Vlah and Raška are the most visited parts of our country. The values of this area are described in detail in the analysis of the level of natural and anthropogenic values, as well as in the valorization of the same elements and the types of tourist movements that can take place in this area, in fact in the separate tourist regions. Based on the applied methodology, the area of Stari Vlah and Raška is divided into six tourist regions, diverse in terms of the development of tourism and the surface area as well as specific tourist potentials. The developed tourism zone covers a very small area and is represented by only three tourist regions, which is, of course, not satisfactory. In accordance with the position and tourism potentials of this region, further development of tourism is expected to be accelerated. On the map of the perspectives of tourist regions, it is noticeable that the zone with the most favorable conditions for tourism development covers the largest area. It extends over the territory of each of the listed regions, and it is dominant in Tara-Mokra gora, Zlatibor, Zlatar-Uvac-Lim, Golija-Javor. Synthetic maps were created with the help of advanced GIS methods such as kriging, buffer and cluster. They are the basis of further precise analysis in this geospatial matrix. It may be expected that in the future these tourist regions will be the leaders of tourism development in our country.

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