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GEOMATIC METHODS FOR MANAGEMENT PLANNING OF PROTECTED AREAS. CASE STUDY: PANIOVA FOREST, TIMIS COUNTY, ROMANIA

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Abstract

Imaging analysis based on satellite images, RapidEye imagery was used to analyse and characterize Paniova Forest, a Natura 2000 Site. The studied perimeter is located in the Lugoj Plain, Timis County, Romania. A RapidEye satellite scene with 5 - multispectral bands was used. From a morphological point of view, the study area was analysed based on the parameters: Altitude, Slope (degree) and Slope exposure. In relation to DEM, 10 classes of the protected area were obtained (14.76 ha and 368.64 ha), in relation to Slope, 10 classes (0.75 ha and 469.29 ha), and in relation to the Slope exposure 11 classes (4.53 ha and 339.9 ha). The relationship between NDVI and MSAVI was described by a linear equation in relation to Altitude derived from SRTM mission, and by polynomial equations of 2nd degree in relations to Slope and Slope exposure. According to PCA, PC1 explained 67.91% of the variance, and PC2 explained 32.033% variance with reference to DEM classes; PC1 explained 80,927% variance, and PC2 explained 18.576% variance with reference to Slope; PC1 explained 66.592% variance, and PC2 explained 33.235% variance with reference to Slope exposure.

Key words*: Agroforestry area, DEM, model, RapidEye, PCA.*

INTRODUCTION

Land and resource management are old human concerns, even if the terminology has undergone evolutionary changes over time (Henley, 2008; Kwok, 2014; Uddin and Hossain, 2015; Epstein, 2019).

Natural resource management and biodiversity conservation are concerns of high importance, due to their importance in today's society and economy and world perspective (Muralikrishna and Manickam, 2017).

The method of studying and managing the environment and resources has evolved, depending on the level of knowledge, purpose, objectives, but also methods, techniques, facilities that people have had at their disposal (Putzel et al., 2015; Sala et al., 2017; Sivarajah et al., 2017). A crucial role now belongs to artificial intelligence, which can manage, in real time, huge amounts of data and facilitate decision-making (Vinuesa et al., 2020).

Also, the organization and management of the territory have changed over time, with reference to quantitative and qualitative territorial landmarks, but also with the requirements and needs of people, with the new reporting of people compared to the environment.

Satellite imagery analysis is used more and more in many domains, from micro - to macro scale.

In the case of land surfaces areas, the imagery analysis is based on satellite images (Landsat, RapidEye, Modis, etc.), aerial systems (UAV) or ground - based sensors (stationary or in-motion, like vehicles equipped with video cameras) and offers multiple information and benefits for the quantitative and qualitative evaluation of surfaces and management decisions (Alvioli et al., 2018; Baena et al., 2017; Gaw et al., 2019; Hamylton et al., 2020; Libran-Embid et al., 2020; Sala et al., 2020).

Satellite imagery allows near real-time or multi-temporal analysis and facilitates prediction analysis based on models built on multispectral images (Geller at al., 2017; Constantinescu et al., 2018; Pasetto et al., 2018).

Land areas can be analysed and characterized in morphological terms, by land cover, land use, quality status (degradation/pollution/ vulnerabilities, etc.), type and quality of resources,

crop structure, etc. (Smith et al., 2014; Govedarica et al., 2015; Lawley et al., 2016).

MATERIALS AND METHODS

The study aimed to evaluate, from a land morphology point of view, an agroforestry area, based on a satellite image and the creation of parameters and information useful for analysis and management.

The study area was represented by the Natura 2000 Site, Paniova Forest ROSCI0338, located in the Lugoj Plain (West Plain), Timis County, Romania (Figure 1). The area is located at an altitude between 130-250 m, with an average slope of 10° and an area of approximately 1900 ha.

For the analysis of this site, a RapidEye satellite scene from 22.09.2019 was used. RapidEye imagery is provided in 5 spectral bands, namely Blue (440-510 nm), Green (520-590 nm), Red (630-685 nm), Red Edge (690-730 nm) and Near Infrared (760-850 nm).

Based on the spectral bands of the satellite imagery used, 2 vegetation indices were calculated, NDVI and MSAVI, that are among the most used Vegetation Indices today.

Normalized Difference Vegetation Index (NDVI), relation (1), is useful in order to generate an image displaying greenness (relative biomass) (Rouse et al., 1973), and Modified Soil Adjusted Vegetation Index (MSAVI), based on the SAVI index, relation (2), which is used in order to minimize the effect of bare soil (Qi et al., 1994).

$$\mathrm{NDVI} = \left(\frac{NIR - \mathrm{Re}\,d}{NIR + \mathrm{Re}\,d} \right) \tag{1}$$

$$\mathrm{MSAVI} = \frac{2NIR + 1 - \sqrt{(2NIR+1)^2 - 8(NIR - \mathrm{Re}\,d)}}{2} \tag{2}$$

From a land morphology point of view, the study area was analyse based on the parameters: Altitude, Slope and Slope exposure (Figure 2).

Statistical analysis and data processing was performed in ArcGIS v.10.6, MS Excel and with PAST software (Hammer et al., 2001).

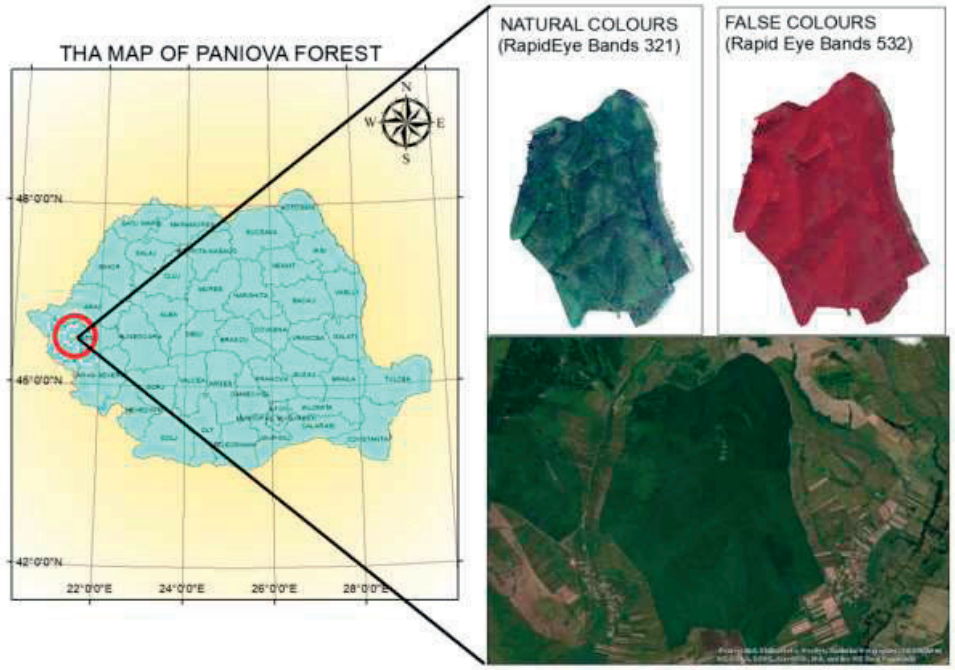

Figure 1. Study area, Natura 2000 Site, Paniova Forest, Timis County, Romania

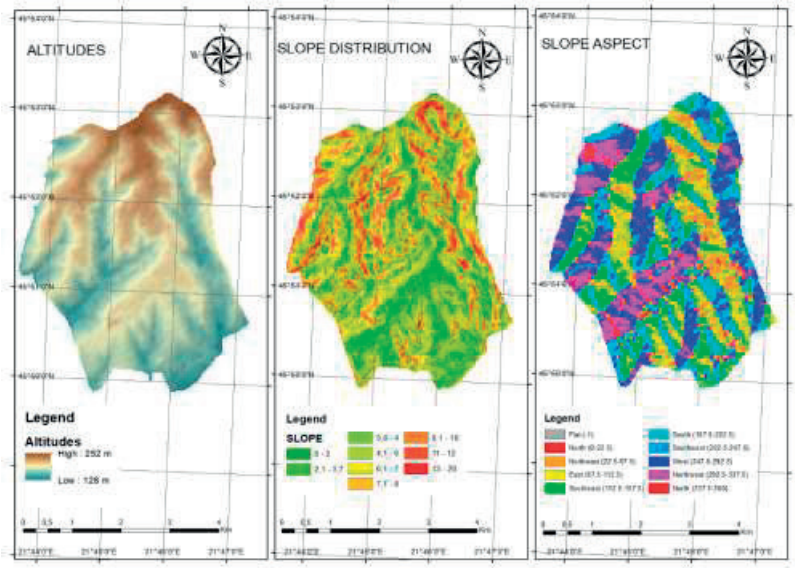

Figure 2. The graphic representation of Altitudes, Slope and Slope exposure for the studied area

RESULTS AND DISCUSSIONS

The land morphology analysis of the studied territory was performed in relation to three important characterization parameters: Altitude, Slope and Slope exposure. In relation to Digital Elevation Model (DEM), 10 arbitrary classes of the protected area were obtained (Figure 3), Paniova forest, with variable areas, between 14.76 ha and 368.64 ha. The NDVI and MSAVI indices (Figure 4) were calculated in relation to the DEM classes obtained, in accordance with the methodology presented in the material and method section, and the results obtained are presented in Table 1. The number of points and related values were generated following the spatial overlapping process.

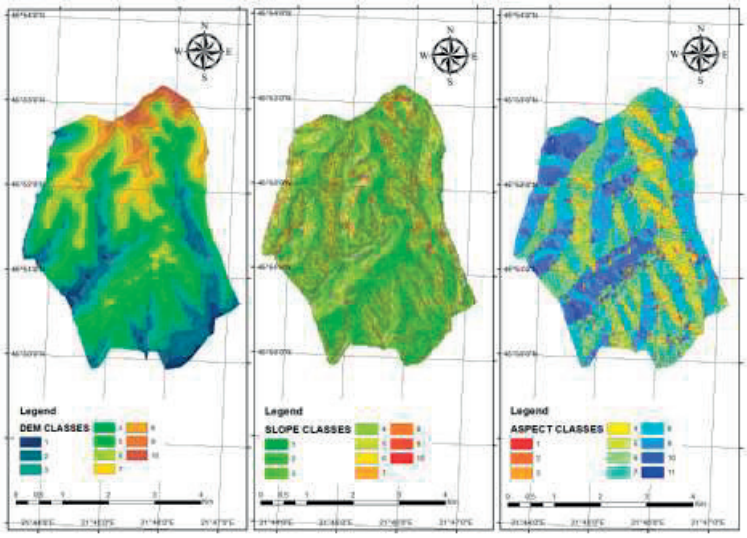

Figure 3. The spatial distribution of the classes

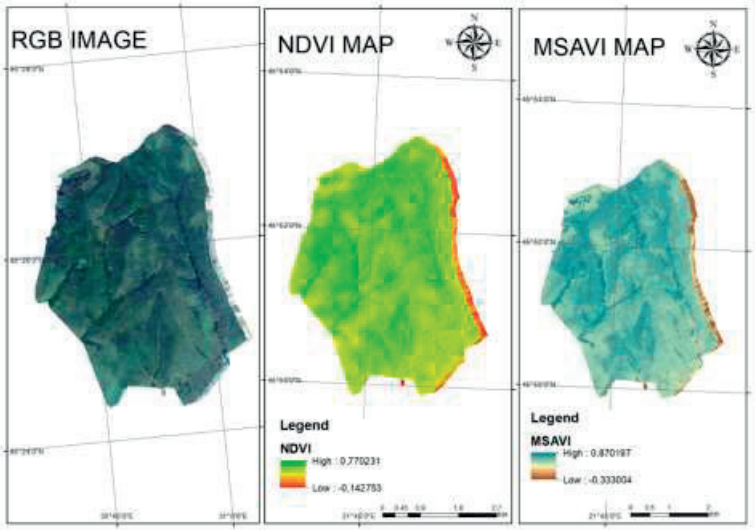

Figure 4. Natural colours RGB image and vegetation indices for the studied area

Table 1. Surface values and indices NDVI and MSAVI on DEM classes, for the protected area Paniova forest

DEM Code	Area		NDVI and MSAVI	NDVI			MSAVI		
	ha	%	Point No	NDVI	Min.	Max.	MSAVI	Min.	Max.
DEM1 <140m	41.97	2.27	17031	0.474282	-0.06424	0.715684	0.63558	-0.13729	0.834275
DEM2 140-152 m	211.01	11.39	86420	0.511829	-0.14275	0.738353	0.673863	-0.333	0.849477
DEM3 152-165 m	313.08	16.90	128614	0.529916	0.079044	0.742211	0.689698	0.146494	0.852025
DEM4 165-177 m	368.64	19.90	151545	0.533219	0.082748	0.770231	0.692206	0.152835	0.870197
DEM5 177-190 m	391.11	21.11	160834	0.546318	0.13221	0.753191	0.704184	0.233526	0.859216
DEM6 190-202 m	228.18	12.32	93835	0.559495	0.070648	0.736411	0.715314	0.131961	0.848191
DEM7 202-214 m	162.90	8.79	66930	0.545339	0.026878	0.742014	0.6989	0.052343	0.851895
DEM8 214-227 m	86.95	4.69	35614	0.552931	0.103157	0.735125	0.706307	0.187006	0.847337
DEM9 227-240 m	33.70	1.82	13807	0.567751	0.122201	0.72336	0.722041	0.217739	0.839466
DEM10 240-252 m	14.76	0.80	6023	0.533198	0.057067	0.684788	0.68757	0.107964	0.812896
TOTAL	1852.30	100.00	760653	0.537538	-0.14275	0.770231	0.695567	-0.333	0.870197

In this regard, based on spatial overlapping, a grouping of NDVI and MSAVI values was made by DEM classes, and the result was an identical number of NDVI and MSAVI points for each DEM class, Table 1. For each DEM class, the average NDVI and MSAVI values were calculated, as well as and the variation interval min - max, and the obtained results are presented in Table 1.

The variation of the vegetation index (NDVI) according to the MSAVI values, in relation to the structuring of the territory on the 10 DEM classes, is described by a linear equation, equation (3), under conditions of R^2=0.992, p<0.001, F=1036.2. The graphical distribution is shown in Figure 5.

$$NDVI = 1.093\,MSAVI - 0.2219 \quad (3)$$

The PCA analysis (Principal Component Analysis) of the distribution of DEM classes, for the studied area Paniova forest, according to Area, MSAVI and NDVI, is shown in Figure 6.

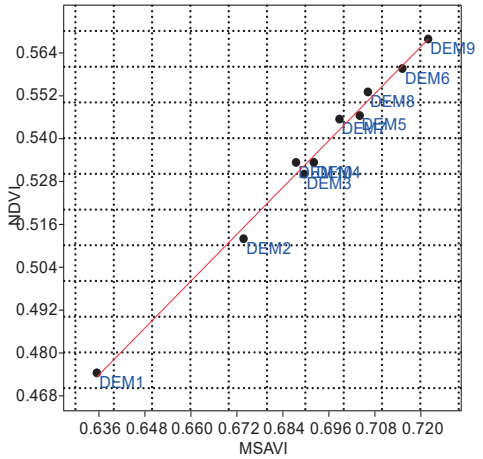

Figure 5. Graphic distribution of values NDVI according to MSAVI, under the conditions of 10 DEM classes

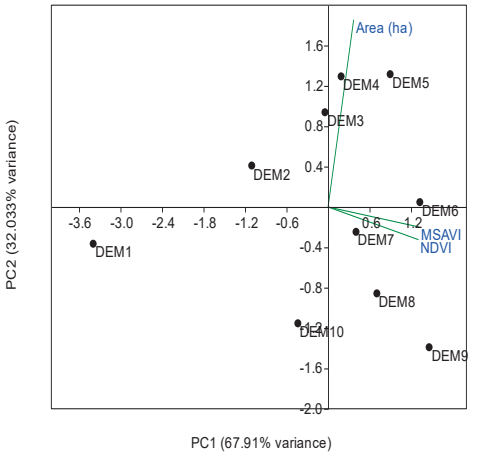

Figure 6. PCA distribution diagram of DEM classes, with reference to Area, NDVI and MSAVI

PC1 explained 67.91% variance, and PC2 explained 32.033% variance.

The cluster analysis, based on Euclidean distances, led to the grouping of DEMs according to MSAVI and NDVI values, in conditions of high statistical accuracy, From the analysis of SDI values (similarity and distance indices) it was found that high levels of affinity were recorded, in descending order, between DEM3 and DEM10 (SDI = 0.003912), followed by DEM10 with DEM4 (SDI = 0.004637), DEM5 with DEM7 (SDI = 0.005374), and between DEM5 and DEM8 (SDI = 0.006946), respectively; Coph.corr = 0.903 (Figure 7).

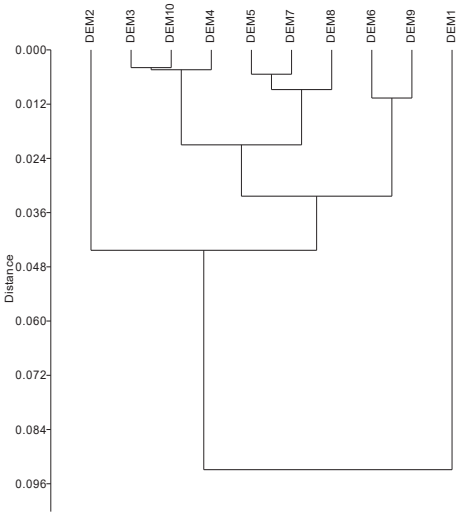

Figure 7. Cluster grouping of DEMs according to MSAVI and NDVI values

In relation to the Slope parameter, for characterizing the land morphology, 10 classes of the protected Area were obtained, Paniova forest, with variable surfaces, between 0.75 ha and 469.29 ha (Table 2).

NDVI and MSAVI indices were calculated in relation to the Slope classes obtained. To this purpose, a grouping of NDVI and MSAVI values was made on the 10 Slope classes, and the result was an identical number of NDVI and MSAVI points, within each Slope class (Table 2).

On each Slope class the average NDVI and MSAVI values were calculated, as well as the variation interval min. - max., and the obtained results are presented in Table 2.

The variation of the vegetation index (NDVI) according to the MSAVI values, in relation to the structuring of the territory analysed on the 10 SLOPE classes, is described by a polynomial equation of 2nd degree, equation (4), in conditions of $R^2 = 0.974$, $p < 0.001$, $F = 132.16$.

$$NDVI = -24.63MSAVI^2 + 35.71MSAVI - 12.39 \quad (4)$$

Table 2. Surface values and indices NDVI and MSAVI by Slope classes, for the protected area Paniova forest

Slope Code	Area		NDVI and MSAVI	NDVI			MSAVI		
	ha	%	Point No	NDVI	Min.	Max.	MSAVI	Min.	Max.
SC1 <1.8^0	200.83	10.84	80347	0.537147	0.114445	0.722472	0.696393	0.20537	0.838869
SC2 1.8^0-3.7^0	428.18	23.12	171401	0.538453	0.062184	0.735125	0.69732	0.117066	0.847337
SC3 3.7^0-5.6^0	469.29	25.34	187836	0.53982	0.071918	0.742185	0.697892	0.134174	0.852007
SC4 5.6^0-7.5^0	392.36	21.18	157098	0.54384	-0.14275	0.748943	0.701088	-0.333	0.856445
SC5 7.5^0-9.4^0	234.24	12.65	93841	0.54339	0.070648	0.770231	0.70059	0.131961	0.870197
SC6 9.4^0-11.3^0	88.59	4.78	35592	0.539282	0.079044	0.749304	0.696848	0.146494	0.856681
SC7 11.3^0-13.2^0	28.16	1.52	11269	0.547272	0.106107	0.740233	0.70404	0.191841	0.85072
SC8 13.2^0-15.1^0	7.77	0.42	3124	0.541873	0.11385	0.719989	0.698882	0.204409	0.837192
SC9 15.1^0-17.00^0	2.13	0.11	868	0.552215	0.174248	0.702322	0.708267	0.296761	0.825124
SC10 17.00^0-18.9^0	0.75	0.04	293	0.548592	0.358688	0.66198	0.707085	0.527967	0.796602
TOTAL	1852.3	100.00	741669	0.540632	-0.14275	0.770231	0.698679	-0.333	0.870197

The graphical distribution is shown in Figure 8. Both from the analysis of equation (4) and from the graphical distribution (Figure 8), an increase was found of NDVI values along with MSAVI values, which indicates a close connection of NDVI index values with MSAVI.

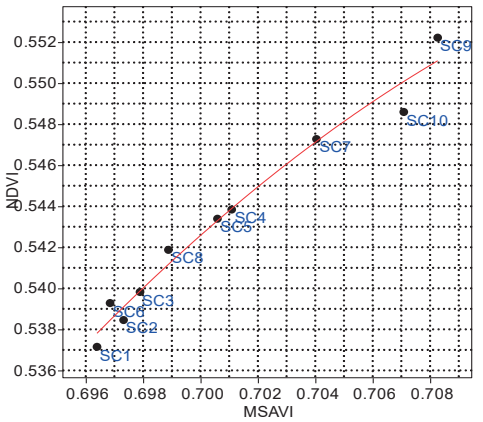

Figure 8. Graphical distribution of NDVI values according to MSAVI, and reference to Slope classes

The PCA analysis of the distribution of SLOPE classes, for the studied area Paniova forest, according to Area, MSAVI and NDVI, is shown in Figure 9. PC1 explained 80.927% of variance, and PC2 explained 18.576% of variance.

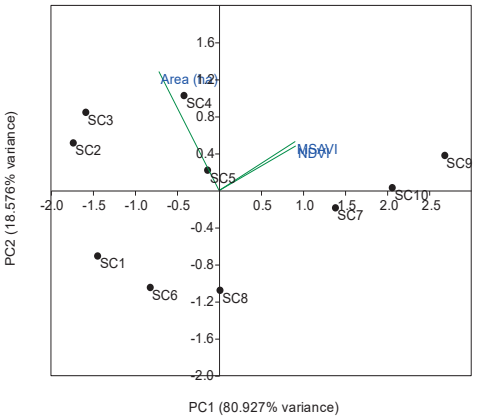

Figure 9. PCA distribution diagram of the Slope classes for Paniova, in relation to Area, NDVI and MSVI

The cluster analysis based on Euclidian distances, led to the association of the 10 Slope groups according to MSAVI and NDVI values, in conditions of high statistical accuracy, Coph.corr = 0.831 (Figure 10). From the analysis of SDI values (similarity and distance indices) it was found that high affinity levels of Slope class (SC) were recorded, in descending order, between SC4 and SC5 (SDI = 0.000671), followed by SC2 and SC6 (SDI = 0.000953), SC6 and SC3 (SDI = 0.001174) and respectively between SC5 and SC8 (SDI = 0.002284).

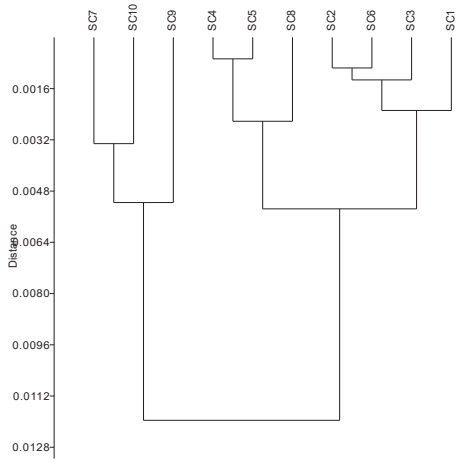

Figure 10. Dendrogram for Slope depending on MDVI/ MSAVI affinity

In relation to the Slope exposure parameter, to characterize the land morphology, 11 classes of the studied area were obtained in Paniova forest, with variable areas, between 4.53 ha and 339.9 ha (Table 3).

Indices NDVI and MSAVI were calculated in relation to the Slope exposure classes obtained. In this purpose, a grouping of NDVI and MSAVI values was made on the 11 Slope espouser classes and the result was an identical number of NDVI and MSAVI points within each class (Table 3).

On each Slope exposure class, the average values NDVI and MSAVI were calculated, as well as the variation interval min - max, and the results obtained are presented in Table 3.

The variation of the vegetation index (NDVI) according to the MSAVI values, in relation to the structuring of the analysed territory on 11 Slope exposure classes, is described by a polynomial equations of 2nd degree, equation (5), in conditions of $R^2 = 0.983$, $p < 0.001$, $F = 226.44$. The graphical distribution is shown in Figure 11.

$$NDVI = 9.781 MSAVI^2 - 12.61 MSAVI + 4.564 \quad 5)$$

Table 3. Surface values and NDVI and MSAVI indices by Slope exposure classes, for the protected area Paniova forest

Slope exposure Code	Surface		NDVI and MSAVI	NDVI			MSAVI		
	ha	%	Point No	NDVI	Min.	Max.	MSAVI	Min.	Max.
AC1 Flat	4.53	0.24	1856	0.543548	0.38922	0.716774	0.702654	0.560314	0.835013
AC2 Flat - North	7.84	0.42	3226	0.540295	0.182713	0.715698	0.698706	0.308951	0.834284
AC3 North	15.88	0.86	6458	0.540002	0.162756	0.699042	0.699155	0.279928	0.822856
AC4 Northeast	139.94	7.55	56019	0.548942	0.113901	0.742211	0.706829	0.204492	0.852025
AC5 East	298.71	16.13	119476	0.546056	-0.14275	0.743148	0.703512	-0.333	0.852642
AC6 Southeast	287.37	15.51	114999	0.545795	-0.01442	0.770231	0.703243	-0.02925	0.870197
AC7 South t	238.19	12.86	95366	0.537464	0.103157	0.753191	0.696716	0.187006	0.859216
AC8 Southwest	257.96	13.93	103235	0.529474	0.062184	0.735125	0.687595	0.117066	0.847337
AC9 West t	339.9	18.35	135882	0.539202	0.026878	0.742014	0.696579	0.052343	0.851895
AC10 Northwest	223.33	12.06	89309	0.541187	0.137557	0.723656	0.7002	0.241827	0.839666
AC11 North	38.65	2.09	15600	0.53609	0.132655	0.740799	0.695584	0.234219	0.851093
TOTAL	1852.3	100.00	741426	0.540683	-0.14275	0.770231	0.698733	-0.333	0.870197

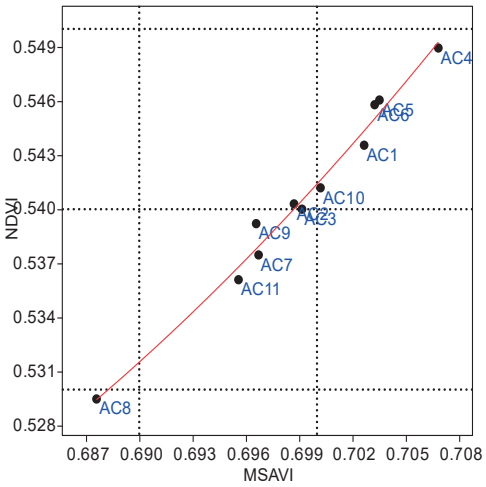

Figure 11. Graphic distribution of NDVI values according to MSAVI, in relation to Slope exposure classes

The PCA analysis of the distribution of the Slope exposure classes, for the studied area Paniova forest, according to Area, MSAVI and NDVI, is presented in Figure 12. PC1 explained 66.592% of variance, and PC2 explained 33.235% of variance.

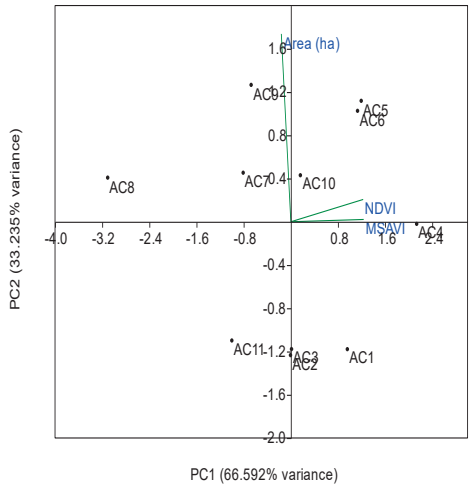

Figure 12. PCA distribution diagram of the Slope expouser classes on the Paniova area, in relation to Area, NDVI and MSVI

The cluster analysis, based on Euclidian distances, led to the association of the 11 Slope exposure classes, depending on the MSAVI and NDVI values, in conditions of high statistical accuracy, Coph.corr = 0.851 (Figure 13).

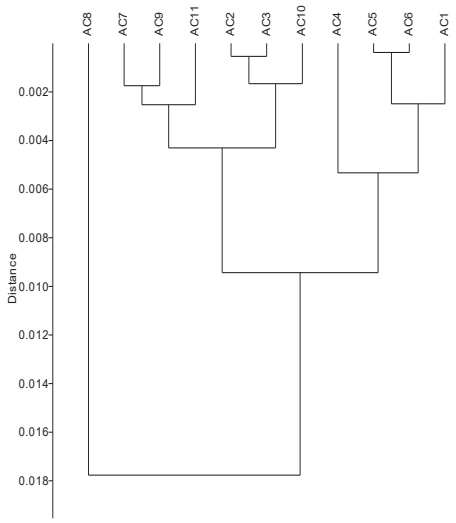

Figure 13. Dendrogram for Slope exposure according to MDVI/MSAVI affinity

From the analysis of SDI values (similarity and distance indices) it was found that high affinity levels of Slope Exposure class (AC) values were recorded, in descending order, between AC5 and AC6 (SDI = 0.000374), followed by AC2 and AC3 (SDI = 0.000536), AC3 and AC10 (SDI = 0.00158), AC7 and AC9 (SDI = 0.001744), and respectively between AC6 and AC1 (SDI = 0.002324).

Imaging analysis based on satellite images is very useful in the analysis and evaluation of the territory for the study of natural or agricultural areas, in order to obtain useful information for monitoring and management of studied areas (Stupen et al., 2018; Todorova and Tcacenco, 2019; Popescu et al., 2020; Stupen et al., 2018).

The morphology of the territory is an important factor of the floristic composition, structure and biomass production of forests. The complex analysis of the data provided information on the landscape heterogeneity of the studied area (Jucker et al., 2018).

The Digital Elevation Model (DEM) has been used in many studies to assess vegetation levels, being considered a very useful parameter especially because the access to certain areas of interest and studied is difficult

(Volarik, 2010). From the point of view of altitude, the studied area is between 130 - 250m, the highest share (approx. 40%) being between altitudes 177-202 m. From the point of view of the inclination (slope), the study area has an inclination between 0°-18°, the highest share (approx. 70%) being in the range of 3°-9°. From the point of view of the slope exposure, the largest share of the area (approx. 16%) is on the East exposure and the lowest on the Nordic and North East exposure.

Paniova Forest, included in the Natura 2000 Site, can also be included in certain objectives and tourist routes, which represents for Romania a high natural potential, reflected by recent studies in the field (Popescu et al., 2020). Similarly, other studies have sought to highlight local resources with high potential for exploitation, broad spectrum or niche (Dobrei et al., 2009; Dobrei et al., 2015).

In relation to the elements of land morphology, Altitudes, Slope, Slope Exposure, characterized in this study, different areas of the studied area can be monitored, regarding aspects of predominant vegetation dynamics (oak), evolution of sub-shrub vegetation, effects of climatic conditions (especially extreme conditions - storms), of current maintenance works (maintenance operation, planting - replanting), interior design, access roads, etc.

This information can be included in the management plan, as benchmarks against which to make a comparative analysis over time, in order to highlight the spatial and temporal variability of the Paniova Forest area.

CONCLUSIONS

Altitudes, Slope and Slope exposure parameters have facilitated the analysis and morphological characterization, on classes with similar properties, of the Paniova Forest area, Natura 2000 Site.

The NDVI and MSAVI indices, associated with the Altitudes, Slope and Slope exposure classes, expressed by the arboreal vegetation in the studied area.

Principal Component Analysis led to the obtaining of distribution diagrams of the classes DEM, Slope, Slope exposure in relation to the indices NDVI and MSAVI, under conditions of statistical accuracy.

The cluster analysis, based on Euclidean distances, facilitated the classification of DEM, Slope and Slope exposure, based on affinity in relation to the values of NDVI and MSAVI indices, and similarity and distance indices (SDI) confirmed the degree of similarity within cluster groups.

This study can be further developed in order to estimate the age of the tree, the biomass of the wood, the health of the trees, the planning of specific interventions in the management of protected areas.

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REFERENCES

Alvioli, M., Mondini, A.C., Fiorucci, F., Cardinali, M., Marchesini, I. (2018). Topography-driven satellite imagery analysis for landslide mapping, *Geomat. Nat. Haz. Risk*, 9(1), 544-567.

Baena, S., Moat, J., Whaley, O., Boyd, D.S. (2017). Identifying species from the air: UAVs and the very high resolution challenge for plant conservation, *PLoS ONE*, 12(11), e0188714.

Constantinescu, C., Herbei, M., Rujescu, C., Sala, F. (2018). Model prediction of chlorophyll and fresh biomass in cereal grasses based on aerial images, *AIP Conf. Proc*., 1978, 390003.

Dobrei, A., Sala, F., Mos, V. (2009). Local grapevine biotypes and varietis - a source for biodivesity, specificity and authenticity, *Bulletin UASVM Horticulture*, 66(1), 260-266.

Dobrei, A., Dobrei, A.G., Nistor, E., Iordanescu, O.A., Sala, F. (2015). Local grapevine germplasm from Western of Romania - An alternative to climate change and source of typicity and authenticity, *Agric. Agric. Sci. Procedia*, 6, 124-131.

Epstein, C. (2019). Natural resource management, *Enciclopedia Britanica Inc.* https://www.britannica.com/topic/ natural-resource-management, (Access Date September, 18, 2020).

Gaw, L.Y.-F., Yee, A.T.K., Richards, D.R. (2019). A high-resolution map of Singapore's terrestrial ecosystems, *Data*, 4, 116.

Geller, G.N., Halpin, P.N., Helmuth, B., Hestir, E.L., Skidmore, A., Abrams, M.J., Aguirre, N., Blair, M., Botha, E., Colloff, M., Dawson, T., Franklin, J., Horning, N., James, C., Magnusson, W., Santos, M.J., Schill, S.R., Williams, K. (2017). Remote sensing for biodiversity. In: Walters M., Scholes R. (eds) *The GEO Handbook on Biodiversity Observation Networks. Springer, Cham.,* 187-210.

Govedarica, M., Ristic, A., Herbei M.V., Sala, F. (2015). Object oriented image analysis in remote sensing of forest and vineyard areas, *Bulletin UASVM Horticulture*, 72(2), 362-370.

Hammer, Ø., Harper, D.A.T., Ryan, P.D. (2001). PAST: Paleontological statistics software package for education and data analysis, *Palaeontol. Electron*., 4(1), 1-9.

Hamylton, S.M., Morris, R.H., Carvalho, R.C., Roder, N., Barlow, P., Mills, K., Wang, L. (2020). Evaluating techniques for mapping island vegetation from unmanned aerial vehicle (UAV) images: Pixel classification, visual interpretation and machine learning approaches, *Int. J. Appl. Earth Obs. Geoinf*., 89, 1-14.

Henley, D. (2008). Natural resource management: Historical lessons from Indonesia, *Hum. Ecol.,* 36(2), 273-290.

Jucker, T., Bongalov, B., Burslem, D.F.R.P., Nilus, R., Dalponte, M., Lewis, S.L., Phillips, O.L., Qie, L., Coomes, D.A. (2018). Topography shapes the structure, composition and function of tropical forest landscapes, *Ecol. Lett.,* 21(7), 989-1000.

Kwok, A.C.F. (2014). The evolution of management theories: A literature review, *Nang Yan Business Journal,* 3(1), 28-40.

Lawley, V., Kewis, M., Clarke, K., Ostendorf, B. (2016). Site-based and remote sensing methods for monitoring indicators of vegetation condition: An Australian review, *Ecol. Indic*., 60, 1273-1283.

Muralikrishna, I., Manickam, V. (2017). Chapter three - Natural resource management and biodiversity conservation. *Environ. Manage*., 23-35.

Pasetto, D., Arenas-Castro, S., Bustamante, J., Casagrandi, R., Chrysoulakis, N., Cord, A.F., Dittrich, A., Domingo-Marimon, C., Serafy, G.E., Karnieli, A., Kordelas, G.A., Manakos, I., Mari, L., Monteiro, A., Palazzi, E., Poursanidis, D., Rinaldo, A., Terzago, S., Ziemba, A., Ziv, G. (2018). Integration of satellite remote sensing data in ecosystem modelling at local scales: Practices and trends, *Methods Ecol. Evol.,* 9(8), 1810-1921.

Popescu, C.A., Herbei, M.V., Sala, F. (2020). Remote sensing in the analysis and characterization of spatial variability of the territory. A study case in Timis County, Romania, *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development,* 20(1), 505-514.

Popescu, A., Hontus, A.C., Caratus-Stanciu, M. (2020). Trends and changes in tourist flow in Romania in the period 2009-2018, *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 20(1), 425-436.

Putzel, L., Kelly, A.B., Cerutti, P.O., Artati, Y. (2015). Formalization as development in land and natural resource policy, *Soc. Nat. Resour*., 28(5), 453-472.

Qi, J., Chehbouni, A., Huete, A.R., Keer, Y.H., Sorooshian, S. (1994). A modified soil vegetation adjusted index. *Remote Sens. Environ*., 48, 119-126.

Rouse, J.W., Haas, R.H., Schell, J.A., Deering, D.W. (1973). Monitoring vegetation systems in the Great Plains with ERTS, Third *ERTS Symposium, NASA,* SP-351 I, 309-317.

Sala, F., Iordănescu, O., Dobrei, A. (2017). Fractal analysis as a tool for pomology studies: Case study in apple, *AgroLife Sci. J.,* 6(1), 224-233.

Sala, F., Popescu, C.A., Herbei, M.V., Rujescu, C. (2020). Model of color parameters variation and correction in relation to "Time-View" image acquisition effects in wheat crop, *Sustainability*, 12(6), 2470.

Sivarajah, U., Kamal, M.M., Irani, Z., Weerakkody, V. (2017). Critical analysis of Big Data challenges and analytical methods, *J. Bus. Res.*, 70, 263-286.

Smith, A.M.S., Kolden, C.A., Tinkham, W.T., Talhelm, A.F., Marshall, J.D., Hudak, A.T., Boschetti, L., Falkowski, M.J., Greenberg, J.A., Anderson, J.W., Kliskey, A., Alessa, L., Keefe, R.F., Gosz, J.R. (2014). Remote sensing the vulnerability of vegetation in natural terrestrial ecosystems, *Remote Sens. Environ*., 154, 322-337.

Stupen, N., Stupen, M., Stupen, O. (2018). Electronic agricultural maps formation on the basis of GIS and earth remote sensing, *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 18(4), 347-352.

Stupen, M., Stupen, N., Ryzhok, Z., Taratula, R. (2020). Methodology of zoning application for agricultural crops cultivation on the basis of space imagery, *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 20(1), 575-580.

Todorova, L., Tcacenco, A. (2019). Study regarding peculiarities of introducing and developing effective digital technologies in the agrifood sector. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 19(4), 341-344.

Uddin, N., Hossain, F., 2015, Evolution of modern management through taylorism: An adjustment of scientific management comprising behavioral science, *Procedia Comput. Sci*., 62, 578-584.

Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Felländer, A., Langhans, S.D., Tegmark, M., Nerini, F.F. (2020). The role of artificial intelligence in achieving the sustainable development goals, *Nat. Commun*., 11, 233.

Volařík, D. (2010). Application of digital elevation model for mapping vegetation tiers, *J. Forest Sci.,* 56(3), 112-120.