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Counting Fuel Properties as Input in the Wildfire Spreading Capacities of Vegetated Surfaces Case of Albania

Abstract

Keywords: *Disaster risk reduction; QGIS; Albania; Analytic Hierarchy Process; NDVI*

Albania as a Mediterranean country is highly vulnerable to forest fires. This is amplified by the emerging effects of global warming and climate change. Extreme weather conditions characterized by increased peak temperatures and stretched draught seasons are expected to become more frequent. In this context, estimations about wildfire ignition probabilities and spread capacities of the territory are crucial. In this paper we bring an update to our previous indexing method for forested lands classification by their wildfire ignition probability (WIPI) and wildfire spreading capacity (WSCI). The original method follows a multi-variable approach by simultaneously considering social, environmental, and physical aspects of the territory. In this version, we push forward four new parameters regarding the fuel properties. We integrate land cover type via Corine Land Cover (CLC), Plant Heat Zones, Tree Cover Density (TCD), and NDVI along with the previous ones. Raw materials and the software are purposely selected from free-accessible sources. This makes the method easier to be reproduced to other study areas. The analytical steps of the process are performed in QGIS software including the Semi-Automatic Classification Plugin (SCP) which is useful in calculating NDVI values. The diversity among the inventory values of the selected criteria urges for a normalizing procedure within QGIS. Besides, each criterion is foreseen to have a specific impact on the WSCI value, which is weighted via Analytic Hierarchy Process (AHP). The sum of the products of the normalized class and the weighted impact factor of each criterion generates the WSCI value. The results of this study provide useful materials in support of wildfire risk reduction within the national priorities of disaster risk management and fire safety in Albania.

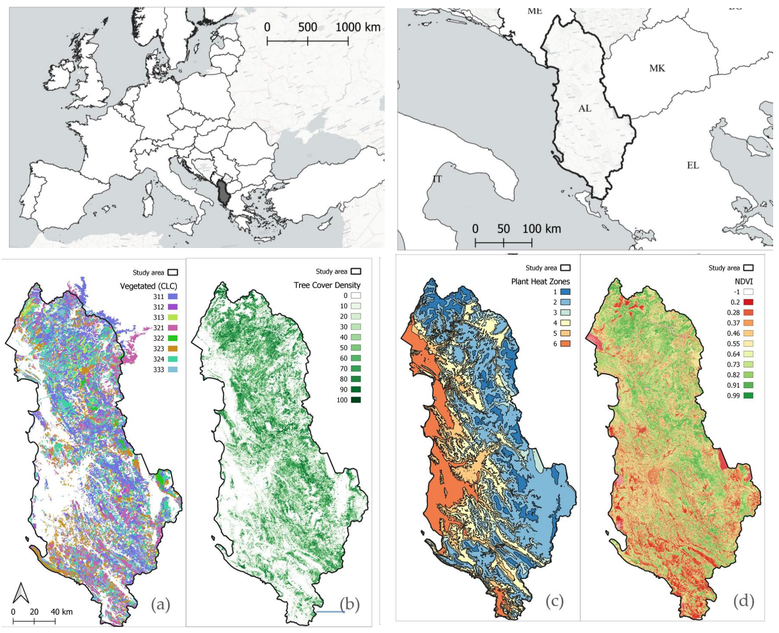


Figure 1. The study area consisting of the territory of the Albanian Republic within Europe including the new four criteria; (a) vegetation type based on CLC data of 2018, (b) tree cover density, (c) plant heat zones, and (d) NDVI.

Materials & Methods

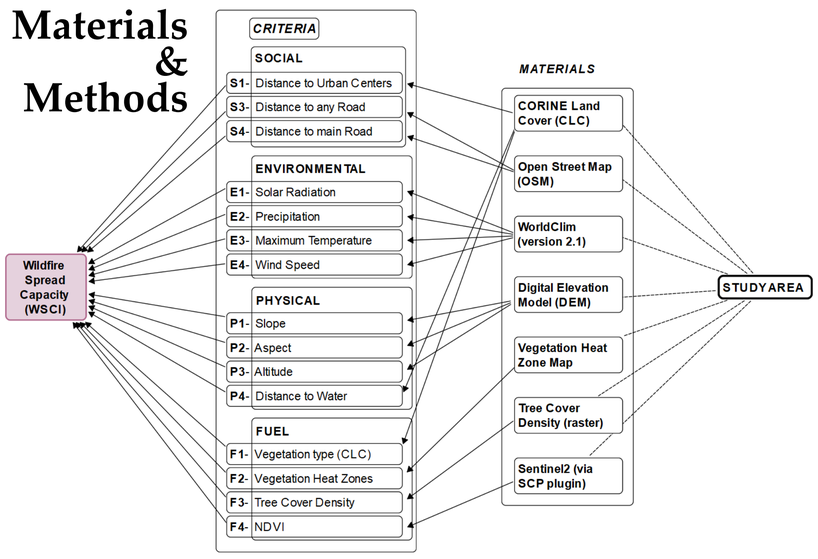


Figure 2. The multicriteria model for WSCI indexing based on social, environmental, physical and fuel properties of the vegetated locations, including the respective raw materials and data sources.

Table 1. The Workflow of the process for calculating WSCI values in QGIS.

	Stage		*Objective*	*Method/ tool/ command*
I	*Initial*	*1*	*Defining the Study Area*	*Extracting vegetated surfaces from CLC data*
		2	*Generating regular points grid*	*Vector/ Research tools/ Regular points (500m)*
		3	*Generate reference points*	*Extracting the points overlapping with vegetated surfaces*
II	*Inventory*	*4*	*Measuring raw values for each criteria*	*"Sample Raster Value" tool for raster data and "Distance to Nearest Hub" for vector layers.*
		5	*Multi-criteria inventory*	*Projecting/converting individual values into raster layer. Aggregating them into the reference points layer via "Sample Raster Value" tool.*
III	*Refinement*	*6*	*Normalizing*	$x' = x - \min(X) \;/\; \max(X) - \min(X)$ (1)
		7	*Defining weighting factors*	*Assign weight to each criteria based on Analytical Hierarchy Process (AHP, pairwise comparison).*
IV	*Indexing*	*8*	*Calculating WSCI*	$WSCI = \sum_{j=1}^{m} \beta_j C_j$ (3)
V	*Validation*	*9*	*Cross-check with burned areas*	*Evaluate the results of the points that fall within the burned areas in comparison with other reference points. (Scatter plot)*

Table 4. Multi-criteria used in WSCI index calculation, including their respective relevancy and their impact factor within and among categories (β_j).

category			*criteria*	*relevancy*	*IF (within category)*	*IF (category)*	*IF (β_j)*
SOCIAL	1	S1	Dist. to Urban Cent	+	0.243	0.071	0.017
	2	S3	Dist. to any road	+	0.088	0.071	0.006
	3	S4	Dist. to main road	+	0.669	0.071	0.047
ENVIRONMENTAL	4	E1	Solar radiation	+	0.046	0.235	0.011
	5	E2	Precipitation	-	0.203	0.235	0.048
	6	E3	Maximum temp.	+	0.094	0.235	0.022
	7	E4	Wind speed	+	0.657	0.235	0.155
PHYSICAL	8	P1	Slope	+	0.271	0.122	0.033
	9	P2	Aspect	+	0.110	0.122	0.013
	10	P3	Altitude	-	0.045	0.122	0.006
	11	P4	Dist to water	+	0.573	0.122	0.070
FUEL	12	F1	Fuel type (CLC)	+	0.122	0.571	0.070
	13	F2	Vegetation Heat Zone	+	0.057	0.571	0.033
	14	F3	Tree Cover Density	+	0.523	0.571	0.299
	15	F4	NDVI	+	0.298	0.571	0.170
						1.00	1.00

Table 3. The inventory results including the upper bound, lower bound and median values of WSCI indexing results.

	Criterion	unit	Upper bound	norm	Median value	norm	Lower bound
E1	Solar radiation	MJ m^{-2}	23390	1	22157	0.678	19561
E2	Precipitation	mm	80	1	49	0.466	22
E3	Maximum temp.	∘C	30	1	24	0.642	12
E4	Wind speed	m s^{-1}	3.6	1	1.5	0.222	0.9
F1	Fuel type (CLC)	reclassify	9	1	6	0.625	1
F2	Vegetation Heat Zone	reclassify	6	1	2	0.333	0
F3	Tree Cover Density	%	98	1	37	0.374	0
F4	NDVI	ratio	1	1	0.67	0.841	-1
P1	Slope	%	89	1	18.5	0.209	0
P2	Aspect	reclassify	10	1	6	0.600	0
P3	Altitude	m	2671	1	891	0.334	-3
P4	Dist to water	m	43791	1	7587	0.173	22
S1	Dist. to Urban Cent	m	44377	1	7147	0.160	39
S3	Dist. to any road	m	11791	1	1329	0.112	5
S4	Dist. to main road	m	21694	1	5093	0.234	11
Result	**WSCI**			**0.682**		**0.390**	
	WSCI normalized			**1**		**0.496**	

Results

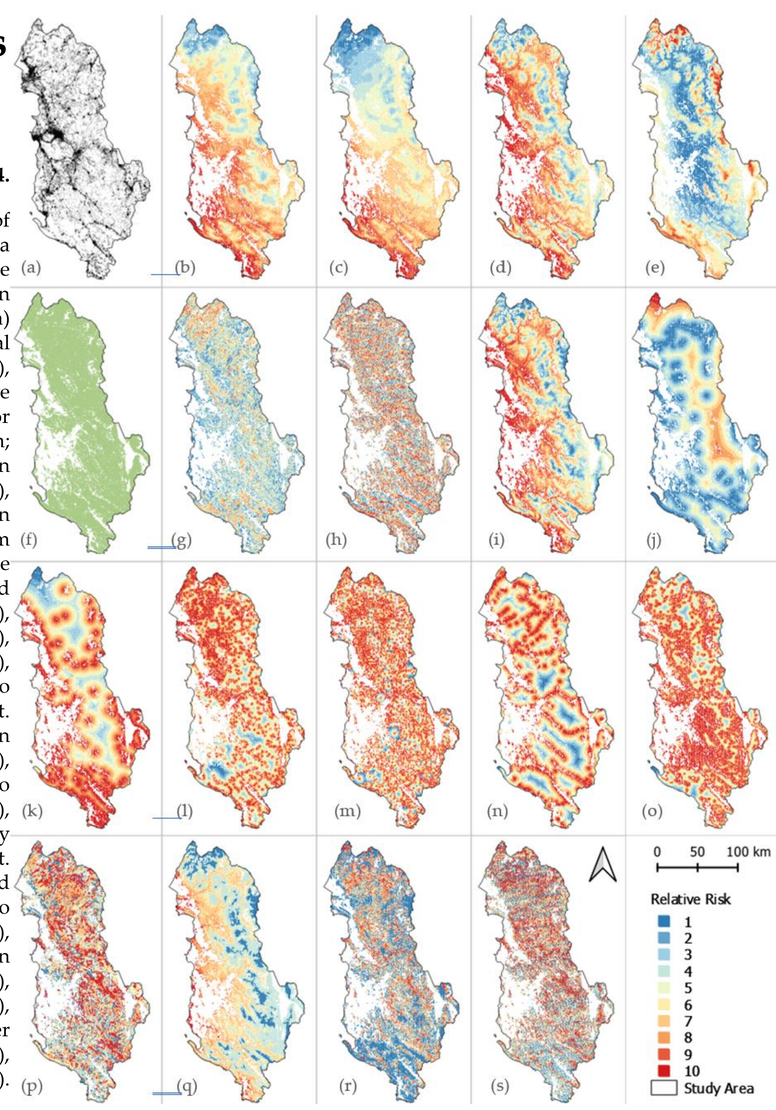
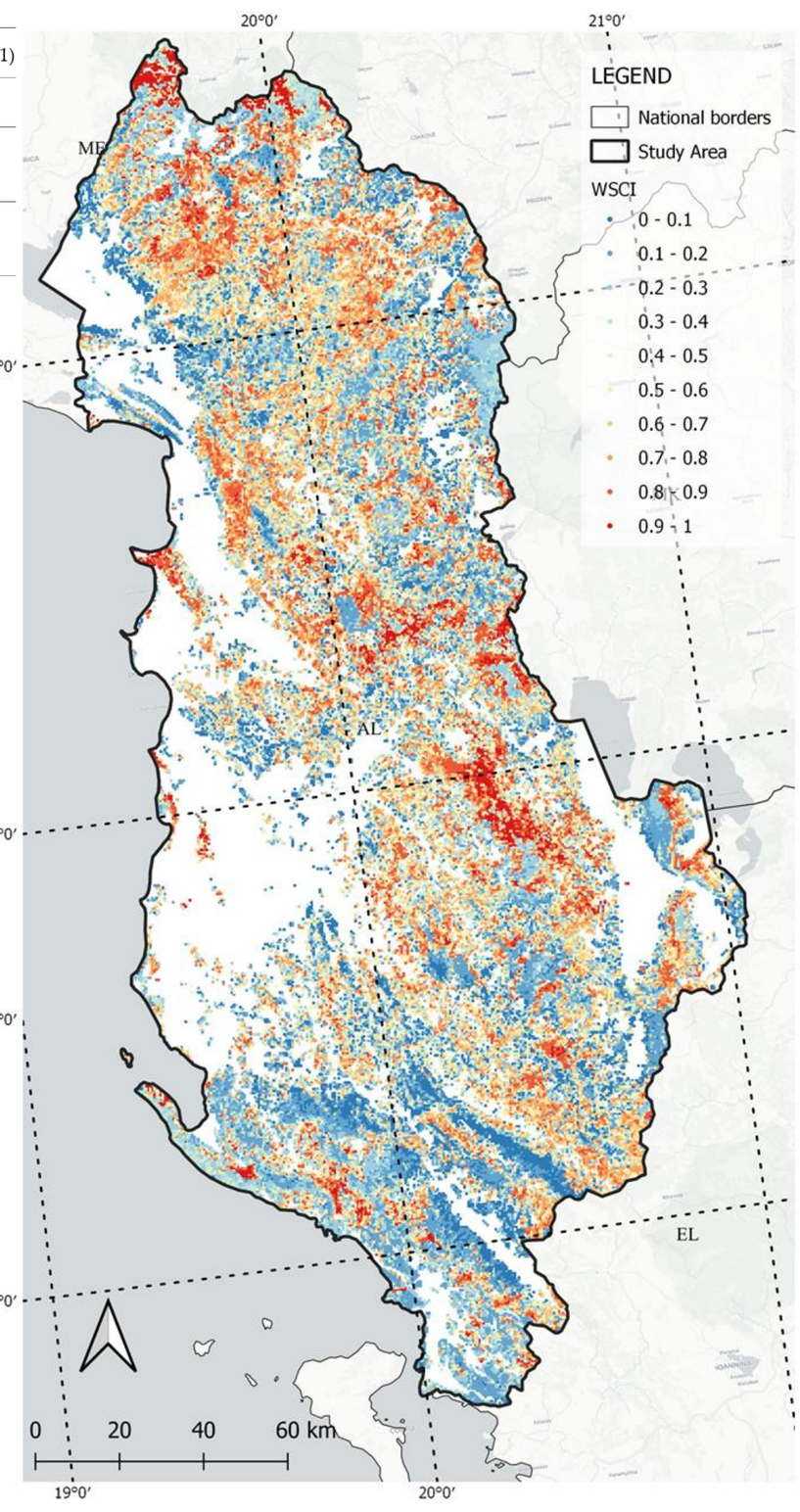


Figure 4. The territory of Albania including the transportation network (a) and natural vegetation (f), and the relative risk map for each criterion; solar radiation (b), precipitation (c), maximum temperature (d), wind speed (e), slope (g), aspect (h), elevation (i), distance to water (j), dist. to urban centers (k), dist. to settlements (l), dist. to any road (m), dist. to main road (n), dist. to agriculture (o), vegetation type-CLC (p), heat zones (q), tree cover density (r), NDVI (s).

Figure 5. The normalized WSCI indexing results for Albanian territory.



Conclusion

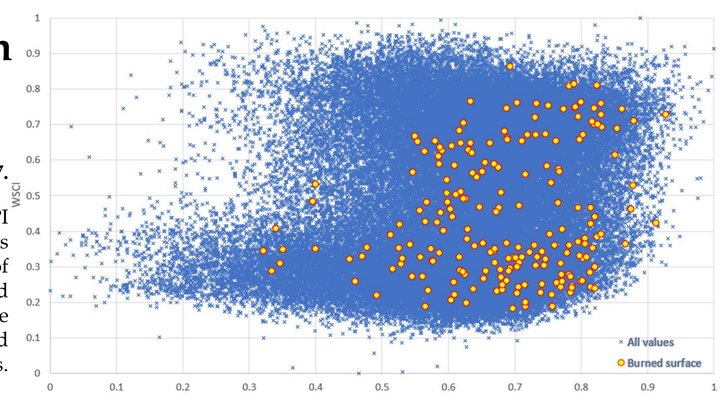
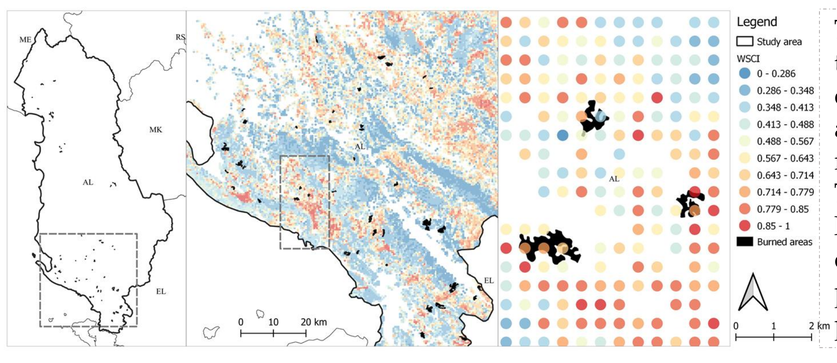


Figure 7. Scatter plot of WIPI to WSCI values where the values of points on burned areas are highlighted in red circles.



This study presented a rapid and cost-free method for classifying the vegetated surfaces of a territory by their wildfire spreading capacities. The proposed method is primarily useful for study areas and regions that lack historical data about the wildfire regimes, which is a frequent condition in developing countries. This is more crucial in regions like western Balkans within the Mediterranean zone, in which the lack of historical data and the current wildfire risk are significant conditions. The method presented in this study can be considered a contribution to the pre-occurrence phase of the wildfire management processes.