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QUANTIFYING LANDSCAPE FRAGMENTATION VIA EFFECTIVE MESH SIZE LANDSCAPE METRIC: CASE OF ALBANIA

SUMMARY

The assessment of landscape fragmentation (LF) in developing regions is vital to support sustainable decision making in managing the accelerating territorial transformations. Albania is a case where the territorial development processes exhibit extensive transformation rates of land use and land cover (LULC). Lack of measurements for the existing situation and the ongoing high rates of LULC alterations are alerting to act. First, for assessing the current fragmentation caused primarily by the road network and land use change, and second, for highlighting regions of significant importance for biodiversity protection. This study aims to address LF assessment by developing an analytical workflow of consecutive steps utilizing QGIS software. Furthermore, we aim to identify the existing degree of LF in Albania through quantitative results after defining key fragmenting geometries. Effective mesh size (*meff*) is selected as the landscape metric to be used in quantifying the assessment of LF in four levels. The materials of our study rely on open access geospatial data like, CORINE Land Cover, open street map, and digital elevation model, which are utilized as raw data of the analytical processes. At this stage the method is flexible enough to be applied in other developing regions. The results derived from *meff* calculation highlighted the extended influence of LF phenomenon, mainly caused by transportation infrastructure and agricultural areas. We push forward this method as a rapid quantitative landscape assessment technique to deliver reliable graphical and statistical results, which are of assistance to institutions responsible of decision-making processes in spatial planning and management in Albania and beyond.

Keywords: Albania, CORINE Land Cover, Effective mesh size, Landscape fragmentation, QGIS

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INTRODUCTION

Landscape fragmentation (LF) is considered as one of the most prominent issues regarding territorial development having negative impact on biodiversity, ecosystems, and quality of life at global, regional, and local levels (Jaeger *et al*., 2011; Ibáñez *et al*., 2014). Recent studies have shown the correlation between LF and consequences like land loss and flooding (Lam *et al*., 2018; Wu *et al*., 2019). The transformation dynamics of land use and land cover (LULC) have direct effect on landscape fragmentation and the shrinkage of natural landscape patches (Sharma *et al*., 2017). These alterations in LULC may lead to snowballing effects like soil erosion at basin level (Spalevic *el at*., 2017).

In order to safeguard the regional and global consequences of the local LULC transformation processes, the scientific community have highlighted the importance of monitoring the LULC transformation dynamics (Lambin and Geist, 2008). Current literature includes various indicators and metrics that have been developed for LF assessment (Llausàs and Nogué, 2012; Frazier and Kedron, 2017). Yet, there is no definitive agreement among scholars about the most effective tools for LF assessment (Almenar *et al*., 2019). However, some of them have been successfully integrated into decision making processes in land use planning.

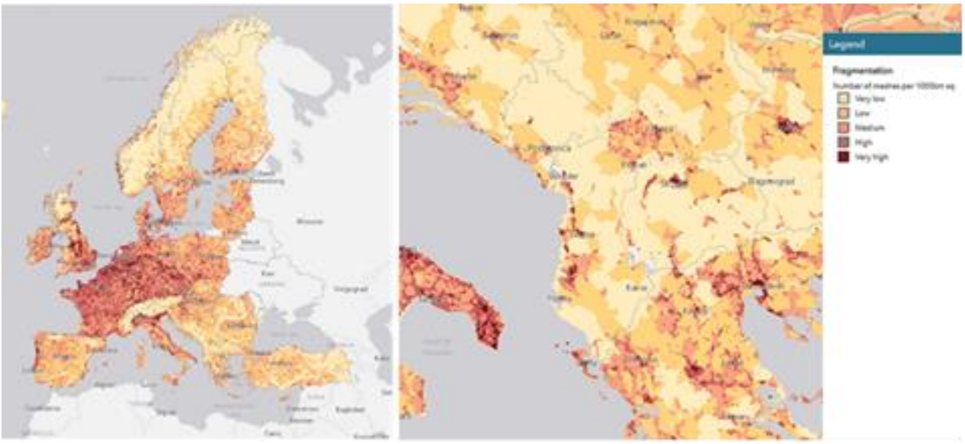

Figure 1: Fragmentation pressure of urban and transport infrastructure expansion in EEA report (EEA, 2018), where Albania is classified among countries with lowest LF degree

The effective mesh size (*meff*) method provides useful and informative data for quantifying LF as a significant input for local and regional planning (Girvetz *et al*., 2008). Despite statistical data, there are produced maps that visualize the LF's spatial distribution, therefore making simpler the identification of habitat areas that are threatened by fragmentation phenomena. *Meff* method has been used in different regions, such as California, France, Germany, and Switzerland. While in developing countries where the landscape transformation rates are accelerating, LF assessment studies are still rare. European Environment Agency (EEA) reports that the fragmentation pressure of urban and transport infrastructure expansion (EEA, 2018) is less in developing European regions compared to the developed countries (see Figure 1).

In this study we bring the case of Albania, a developing country within the Mediterranean basin, with a dynamic structure of natural lands that reflect the unsustainable territorial development (Mullaj *et al*., 2017). Land reclamation programs during the socialist regime between 1945 and 1989 had a great impact on the natural lands and systems (Danermark, 1993; Rugg, 1994; Lusho and Papa, 1998). On the other hand, the post-socialist transition period (1990-ongoing) marks tremendous land use change in the rural, peri-urban and urban lands (Aliaj, 2003; Pojani, 2010). In recent years, the aspiration for EU membership has directed the governmental instances to take actions over sensitive issues in regional and global level, and among them are the sustainable territorial development and biodiversity conservation (Mele, 2017).

There are just a few studies on landscape development issues for the Albanian context. The most tangible ones have been conducted by Hysa and Türer Başkaya (2017) who have initiated an evaluation of LF in Albania with a specific focus on broad-leaved forest surfaces due to their dominant biodiversity and ecological values. This study relied only on the distance between broad-leave forested patches. However, other significant components of LF processes are not considered. Thus, more comprehensive frameworks are needed, which consider not only the fragmented landscapes but also the fragmenting agents.

The main objective of this study is to propose a practical and comprehensive GIS-based workflow for assessing the LF in Albania based on *meff* methodology. Furthermore, we tend to promote the utility of open source tools like QGIS, and freely accessible LULC data which can support similar researches in developing countries as the financial support to scientific research is very limited. Finally, we aim to highlight the importance of LF assessment for developing countries like Albania, and to motivate future studies at regional level like the Western Balkans countries. This is important as the region shares many unique trans-boundary landscapes which must be managed collaboratively.

MATERIAL AND METHODS

This empirical study aims to achieve quantitative results on LF in Albania through effective mesh size methodology applied by Girvetz *et al*. (2008). The evaluation is approached in 4 hierarchical stages, to see the impact of each of the fragmenting elements on the *meff* value at national scale. The main tool to conduct this study is QGIS 3.4. software. The raw materials rely on the open source data like CORINE Land Cove (CLC), open street map (OSM), and digital elevation model (DEM) (see Table 1).

CLC data are used as a medium for landscape fragmentation assessment, by reclassifying the land cover classes according to the methodology approached in this paper. OSM open source data provides the main spatial information about the road network geometries, which are the core fragmenting agents during the first two levels of LF assessment (FG1 and FG2). Consequently, OSM layer is attached to the CLC reclassification, using QGIS overlay techniques to classify four fragmenting geometries that will be the input material for *meff* assessment.

Table 1. Raw materials and the respective sources

Material	**Type**	**Description**	**Source**
CORINE Land Cover	vector	CORINE Land Cover is an inventory of 44 land cover classes. It uses a Minimum Mapping Unit of 25 ha and a minimum width of 100 m for linear features*.	Copernicus Portal**
OSM (open street map)	vector	OSM data is a free source. It provides data derived from the Open Street Map Project, such as transport infrastructure***.	OSM/Geofabric****
DEM	raster	Digital Elevation Model is a representation of terrains surface in 3D. We used the EU-DEM v1.1 data.	Copernicus Portal

* The description of CLC has been referred to Copernicus Portal descriptive sections.
** https://land.copernicus.eu/pan-european/corine-land-cover
*** Geofabrik website, Open Street Map section.
**** http://download.geofabrik.de/europe/albania.html

Study area

Albania is a small developing country in the south-eastern Europe, in Balkan Region (see Figure 2), with a dynamic background in its territorial development history. It has a unique natural setting character which is rich in landscape diversity and climate conditions (Mullaj *et al*., 2017). Even though Albania is a small country covering not more than 0.3% of the total area of European territory, it has more than 30% of flora and fauna found in Europe (Mullaj *et al*., 2017). This fact highlights the importance of landscape conservation and the weight of landscape interventions' consequences in Albanian territory at regional level.

The landscape of Albania is quite fragmented (Mullaj *et al*., 2017), testifying the inadequate territorial development history because of the conflicting and unwise political managements of the territory. The first threshold of land cover transformation was during communist regime with a polarized urban development, and agricultural and industrial expansion through deforestation, affecting thoroughly the landscape quality and natural capital (Rugg, 1994; Naka *et al*., 2002). Afterwards, the post-socialist period was confronted with chaotic land management because of the uncontrolled urban expansion since the 1990s (Cungu and Swinnen, 1998; Pojani, 2010). Since then, urbanization has been associated with relatively large transportation infrastructure projects, and other infrastructural mega projects such as hydropower plants and Trans-Adriatic Pipeline (TAP). These projects are considered negative pressures to the landscape and the surrounding habitat (Dervishi and Hysa , 2018).

The attempts of national instances to preserve and maintain natural resources have been increasing recently; some of the actions are Territorial and Administrative Reform, the law on freezing all construction permits in national level during 2014-2016 period (Mele, 2017; Hysa and Türer Başkaya, 2018), and the evidence from the State of Environment Report (SoER) that government recently has been giving priority to the re-evaluation and expansion of protected areas (Dervishi and Hysa, 2018).

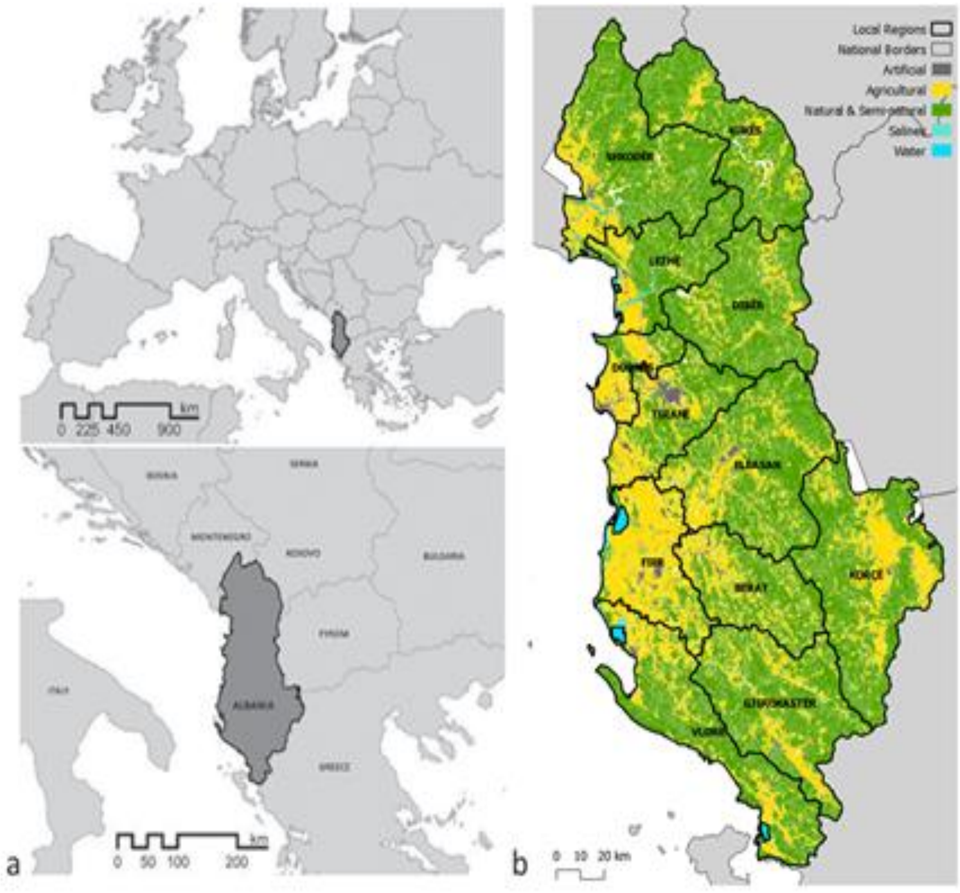

Figure 2: Albania within Europe (a) and the administrative regions and the main land cover classes (CLC-2018) (b)

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However, the only assessment on landscape dynamics is the CLC data being regularly produced in a 6 years interval. Initiating a LF assessment in Albania, Hysa and Türer Başkaya (2017) have conducted a study utilizing Matrix Green Toolbox, and CLC data, to investigate the connect-ability of fragmented patches through edge to edge links, with a focus in the broad-leaved surfaces. They propose the consideration of environmental criteria in the decision-making process of TAR in similar geographies like Albania, as a substantial mediator that could lead to a sustainable management of cross-border natural landscapes, thus reducing the LF impact in country and regional level (Hysa and Türer Başkaya, 2018).

The results from the EEA report (2018) demonstrate that the fragmentation pressure in Albania is very low relative to the regional level (see Figure 1). It is of importance to mention that this evaluation has considered as fragmentation agents only transportation infrastructure network, and urbanized areas. Lekaj *et al*. (2019) have concluded that from 2000-2018 agricultural and wetland areas decreased by 3529.5 ha due to anthropogenic factors referring to the LULC analysis of ultramafic areas in Albania. Similar studies bring out the LF phenomenon in Albania at specific layers/context mainly caused by human development. Thus, the inclusion of other anthropogenic activities like agriculture must be considered as fragmenting agents.

Meff size as a method for Landscape Fragmentation assessment

Effective mesh size (*meff*) is a landscape metric first proposed by Jaeger (2000). It is defined as an expression of the probability that any two locations in the landscape are connected and not separated by barriers (such as roads, railways, rivers, etc) (Jaeger, 2000; 2007). It can also be interpreted as the average size of the area that an animal placed randomly in the landscape will be able to access without crossing barriers (Jaeger, 2002). Thus, *meff* measures landscape both inter-connectivity between patches and intra-connectivity within patch (Girvetz *et al*., 2008; EEA,2018), according to Equation 1.

$$m = \frac{1}{A_t} \sum_{i=1}^{n} A_i^2 \qquad \text{(Equation 1)}$$

where n is the number of patches, A_1 to A_n represent the patch sizes from patch 1 to patch n, and A_t is the total area of the region investigated.

The method by Girvetz *et al*. (2008) was referred to in this paper due to the inclusiveness of fragmenting elements in *meff* calculation, which leads to a more realistic LF value. They categorize the fragmenting geometries in 4 hierarchical levels; each higher level of fragmentation geometry builds on the previous one (see Table 2.). The first two levels rely on the road network which have direct ecological effect on living communities (Trombulak and Frissell, 2000).

Table 2 illustrates the set of fragmenting elements considered in this study. Some classes of CLC and OSM were excluded considering the compliance of the elements to each fragmentation geometry. For instance, for FG2-minor roads dataset it was excluded the ‘bridleway’, ‘footway’, and ‘path’ classes because of their natural character; for FG3-agricultural areas dataset the excluded classes are clc244 ‘agro-forestry’, clc231 ‘pastures’, and clc223 ‘olive groves’ since we did not consider them as artificial barriers. Regarding the FG4 elements, it was revised the minimum height for alpine areas by considering the Albanian geomorphology and territorial character. In the case of Albania, the mountainous geography reaches the highest peak with Korabi Mountain at 2751 meters. Thus, we decided to revise the limit for alpine lands from 3000 m (Girvetz *et al.*, 2008) to 2000 m.

Table 2. Summary table of fragmenting elements used to define each fragmentation geometry (after Girvetz *et al.*, 2008).

	Fragmenting elements	**OSM and CLC input layers**
FG1	Highways	osm: highways
	major roads	osm: motorway, motorway link; primary, primary link; secondary, secondary link; tertiary, tertiary link; trunk, trunk link
	railroads	osm: railroads
	urbanized areas	clc: 111, 112, 121, 122, 123, 124, 131, 132, 133
FG2	FG1 and minor roads	osm: cycleway, living street, pedestrian, residential, service, steps
FG3	FG2 and agricultural areas	clc: 211, 212, 221, 222, 242, 243
FG4	FG3 and lakes, major rivers, alpine areas	Lakes, major rivers, alpine areas above 2000m

Workflow of the study

The work process for LF assessment in this study is entirely conducted through QGIS 3.4 software and organized in 4 sequential phases; adjustment of base material (A), classification of FG layers (B), calculation of area and *meff* values (C), and a concluding step to visualize the results of *meff* for each FG layer (D) (Table 3.1 and Table 3.2). The Table 3 illustrates each step utilized in QGIS through specific toolbox commands, and the input and output layers extracted during the FG1 process phases. The steps are hierarchically applied, following the logic of adding geometries over the earlier one (see Table 2).

Table 3.1The workflow for assessing the Level 1 of LF (FG1) in QGIS

		Step/Reason	**Input Layer**	**Toolbox**	**Output Layer**
A	1	Fixing the geometries to avoid errors in processing.	CLC2018	Fix geometries	CLC_fixed geometries
	2	Unifying CRS from 4043 to3035	CLC2018	Export	CLC_2018
	3	Prepare base material to be used in FG classification.	CLC2018	Clip -Fix geometries	CLC_clip

Table 3.2 The workflow for assessing the Level 1 of LF (FG1) in QGIS

		Step/Reason	Input Layer	Toolbox	Output Layer
B	4	Select the land cover classes in *clcAlb_clipped* layer that will be included in *FG1_natural* layer.	CLC2018-FG1	Select by expression /dissolve	CLC2018-FG1-natural
	5	Import OSM roads layer for Albania. *Fix_clipped_roads* to select the roads included in FG1.	OSM-Roads	Export/clip /select by expression	CLC2018-FG1-roads
	6	Dissolve the layer and then add the buffer value (7.5m) for it.	CLC2018-FG1	Dissolve - buffer	CLC2018-FG1
	7	Clip OSM railways layer to *study area borders* layer.	OSM-Railways	Export/ clip/ buffer	CLC2018-FG1-rail
	8	Merge roads and railways into *FG1_transport*. Dissolve and buffer (7.5m) the output layer.	CLC2018-FG1	Merge /Dissolve/ buffer	CLC2018-FG1-transport
	9	Fragmentation of FG1 natural layer by FG1 transport layer.	CLC2018-FG1	Fragscape–Split	CLC2018-FG1-frag.
C	10	Extracting the ‘Area’ for each fragmented patch.	CLC2018-FG1	Field calculator	
	11	Removing the patches smaller than 25ha**	CLC2018-FG1	Extract by attributes	
	12	Extracting the Sum=Total Area (Area_Total).	CLC2018-FG1	Basic statistics	Statistics html file
	13	Calculating Meff individual: ‘Area’ * ’Area’/ ’Area Total’	CLC2018-FG1	Field Calcuclator	Meff_ind
	14	Extracting the Sum=Meff Total (Meff_total).	CLC2018-FG1	Basic statistics	Statistics html file
D	15	Export the *Fragmentation_FG1_natural* layer after meff calculations, as *FG1_meff*.	CLC2018-FG1	Export–save features	CLC2018-FG1-meff
	16	Apply the categorization of patches according to *meff* value.	CLC2018-FG1_meff	Symbology categorized	Map

** This is due to the MMU of CLC data, considering the smaller patches as accidental during splitting operation.

RESULTS AND DISCUSSION

This research paper provides evidence of LF level through empirical results which are derived from *meff* calculation. The objective is to have a complementary work to achieve a more inclusive database for LF assessment in Albania. The results derived from this study display a total *meff* value decreasing when fragmentation geometries are added hierarchically, from FG1 to FG4.

According to the results presented in Table 4, the *total meff* value for FG1 is 184727ha, FG2 is 101628 ha, FG3 is 90102 ha, and FG4 is 27898 ha. LF increases with the decreasing of *total meff* value, respectively from FG1 to FG2 decreases by 44.9%, from FG2 to FG3 by 6.3%, from FG3 to FG4 by 33%, and in total from FG1to FG4 by 84.9% (see Figure 3b). Number of patches is another indicator of LF degree for each level of FG. The number of patches increases from FG1 to FG2 by 591 patches, from FG2 to FG3 by 62 patches, and from FG3 to FG4 by 573 patches (see Figure 3a).

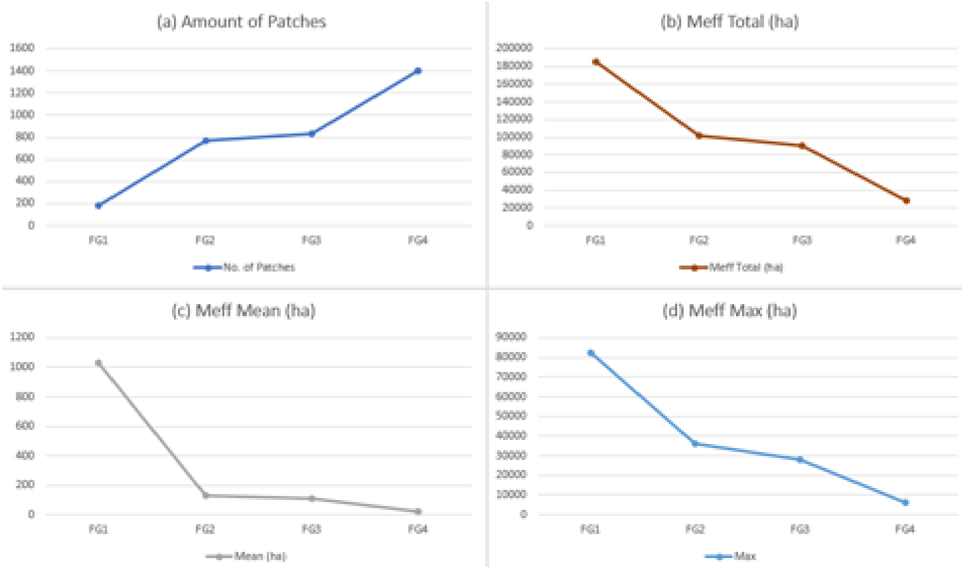

Figure 3: Meff values: (a) Amount of Patches, (b) Meff Total, (c) Meff Mean, (d) Meff Max.

These values highlight the highest impact of level 1 and 2 of urbanized and transportation network fragmenting geometries (FG1 and FG2), followed by natural features included in level 4 (FG4). On the other hand, agricultural areas seem to have the lowest impact in fragmentation of the landscape, although they reduce a considerable amount of the 'Total Area' by 7008 ha (see Table 4). This can be due to their proximity to urbanized areas which already have been calculated in FG1 and FG2, minimizing the impact of agricultural surface.

Comparing 'Mean' and 'Max' values it is noticed that the fragmentation of landscape into small and isolated patches is higher when transportation infrastructure layer is added in FG1 and FG2 (see Figure 3c and 3d); mean value is the average *meff* value relative to the number of total patches and gives an overall idea of the fragmentation degree; maximum value is the highest *meff* value (the largest and less fragmented patch).

Natural features seem to have approximately the same impact as transportation networks and urban settlements. Considering the geographic context of Albanian territory, predominant natural elements such as lakes, high mountains and rivers are mainly concentrated in the Eastern part of the country (see Figure 4). This region is less urbanized compared to the western part of the country. Therefore, FG4 *meff* value increases significantly.

Table 4. Statistics for Fragmenting Geometries.

	No. of Patches	Area Total (km2)	Mean (ha)	Max	Median	total *meff* (ha)
FG1	179	27695	1032	82363	0.013	184727
FG2	770	27417	131	35967	0.007	101628
FG3	832	20409	108	27998	0.003	90102
FG4	1405	18748	19	5935	0.005	27898

Visual representation of *meff* values for each individual patch contributes for more tangible results, by adjusting the LF spatially within the study area (Figure 4). The western part of Albania is highly fragmented, concentrated more in between the central and southern Albania. The main reason is urbanization, transportation infrastructure and industrial development. While the LF being present in the eastern part of Albania is caused by natural features amplification/dominance when calculating FG4.

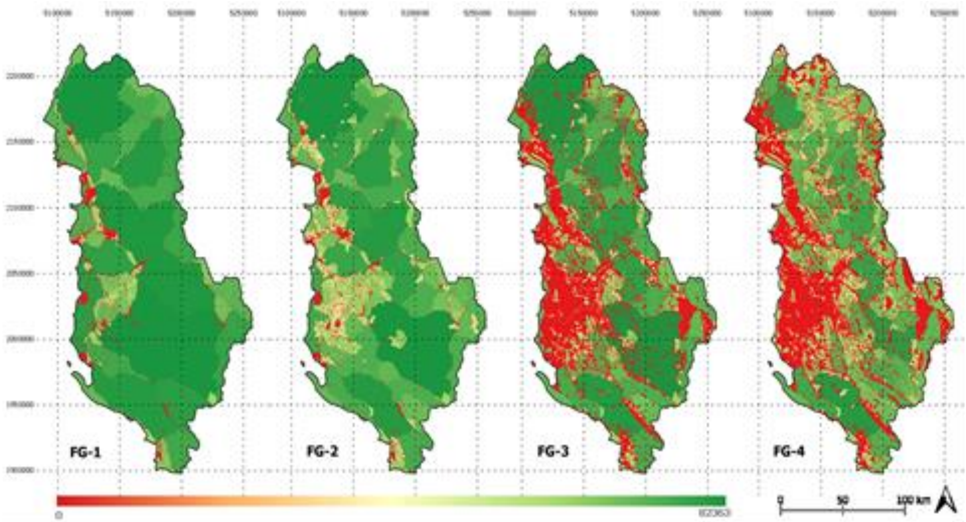

Figure 4: Landscape fragmentation maps for FG-1, FG-2, FG-3, and FG4 according to *meff* results (utilized by QGIS 3.4). *meff* results for each fragmented patch are represented in the legend.

Figure 5 presents the box plot of landscape fragmentation at four levels as a statistical support to the visual information delivered in Figure 4. The *meff* values are represented in logarithmic values to make the interpretation of the results clearer. According to the box plot, there is a continuous decrease in the upper bound of *meff* values while the FG level increases. The upper bound of *meff* values for FG4 is about ten times smaller than the upper bound of FG1. The mean values follow a similar decreasing trend. On the other hand, the lower bound of *meff* values remains the same at minimum values for all fragmentation levels.

The results of upper and lower bounds are supporting the assumption that the increase in fragmenting elements (from FG1 towards FG4, see Table 2.) leads to a decrease of *meff* values. The only unexpected situation is related with the results of the third quartile of FG4. There is a slight increase in the median value and the upper bound of the third quartile of FG4 compared to FG3. The reason behind that could be related with the fragmenting geometries introduced at level 4 (FG4).

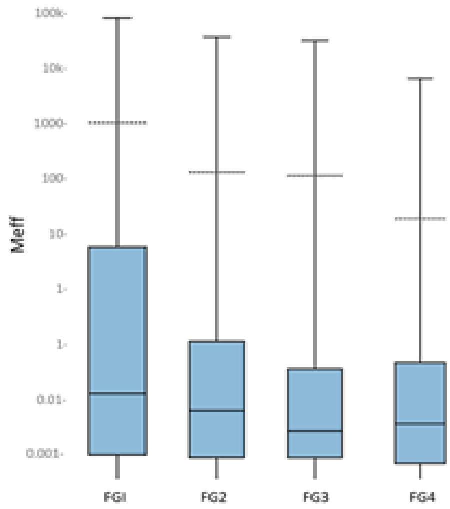

Figure 5: Box plot of landscape fragmentation in Albania represented in logarithmic *meff* values of FG1, FG2, FG3, and FG4.

In the method presented in our work, FG4 is the level in which the water surfaces and alpine lands are introduced as fragmenting agents (see Table 2). Figure 5 implies that the alpine lands (altitude above 2000m) consist of a considerable number of natural areas of small size (low *meff* value). Thus, their reclassification as fragmenting elements result in a slight increase in third quartile of *meff* values for FG4.

The results presented in Figure 6, rely on the spatial distribution of *meff* results per local district as shown in Figure 2. The graph illustrates fragmentation values for each level FG1, FG2, FG3, and FG4 for all districts (Figure 6). Human activity in agriculture and industry is mostly situated in the western Albania region (coastal region). It has greater expansion of national transport arteries, and other human settings.

Districts found in the coastal western and central regions like Lezhe, Durres, Tirane, Fier, and Vlore reflect the highest LF indicated in *meff* values. Durres, Fier, Lezhe and Tirane are the most fragmented regions when compared to other districts. The industrial activity in Albania is mainly concentrated in Durres, Fier, Tirana which is the capital city. Vlore is less fragmented as a result of a minimized human impact in its territory. The uncontrolled urban development in developing counties is accepted to have significant negative impact on natural environments (Parsipour *et al*., 2019).

In the same line, Elbasan, Berat, and Gjirokaster have considerable human activity but are less intense when compared to abovementioned industrial zones. The Eastern part has a predominance of mountainous terrain and the major economic activity for its residents is agriculture. Diber, Kukes and Korce are eastern regions, where Korce seems to be less fragmented, and Kukes is highly fragmented due to natural features and highland characteristics within its boundaries.

Shkoder district is situated in the north-west of Albania. It reflects highest *meff* values in four levels that have been calculated in this inquiry. The lowest *meff* value is noticed in FG4 and this is because of the abundance of natural features like lakes, rivers, and alpine areas. While the records for Berat reports the highest fluctuation of *meff* value among four levels of the analysis. This is due to the vast and diverse amount of natural features in its territory, which lead to high *meff* values at FG1 and significantly low at FG4.

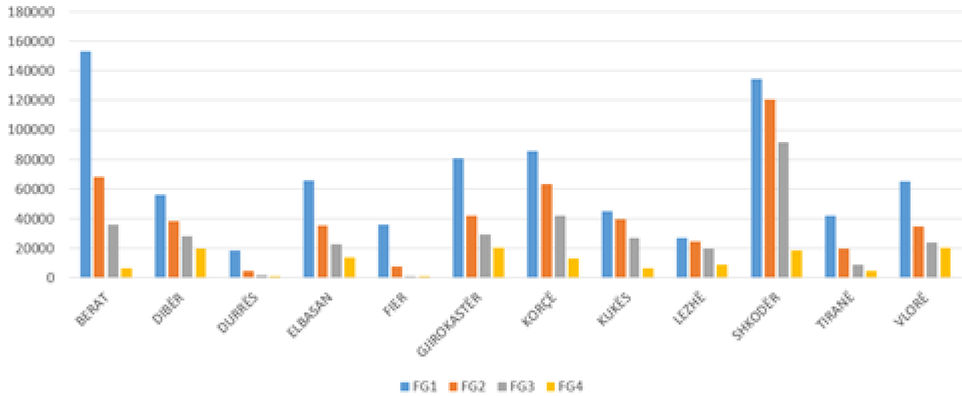

Figure 6: Landscape fragmentation in Albania by administrative regions represented in absolute values of FG1, FG2, FG3, and FG4

Our results confirm the fact that Albanian territory holds a considerable level of LF. The empirical data derived from *meff* calculation supplies evidence that LF in Albania is higher than presented in the EEA report. The method of four calculated levels of fragmentation geometries (FG) intends to analyze how each category reflects the total value of *meff*. Transportation infrastructure results to have the highest impact due to an uncontrolled urban expansion that occurred after the 90s (post-socialist period); as the consequences of urban development in the period between 1990 and 2000 have been irreversible. The transportation network not only fragment the natural lands but also elevate wildfire ignition probability and the human activities interfere to wildland vegetated surfaces (Hysa and Spalevic, 2020).

Similarly, FG4 elements have the same influence in LF degree as transportation networks. Their barrier effect is characterized by surface expansion dividing and at the same time distancing the surrounding habitats from each other. In the case of Albania their impact is very prominent due to its mountainous terrain and richness in blue infrastructure.

LF in Albania has also a considerable impact at regional level, since it has more than 30% of flora and fauna found in Europe (Mullaj *et al*., 2017). This fact addresses LF to be significantly integrated in decision-making actions related to environmental and territorial development programs. LULC dynamic developments such as urban expansion, new infrastructure projects, and agricultural activity are future events that can occur as a result of population growth, consumption, migration, etc.

The results of this inquiry can guide the responsible instances to consider the barrier effect for each category of intervention and foster projects with connectivity character to minimize fragmentation of the territory and improve the minimal requirements of endemic fauna and flora communities. The case of 'Long-Term Defragmentation Programme' in the Netherlands (Nunes *et al*., 2005; van der Grift, 2005) is a vital reference for guiding concrete actions to mitigate the LF. The results are relevant for regional level comparative studies, to promote studies related to landscape degradation and LF causing irreversible loss to biotic communities. Thus, this study can also motivate future studies comparing between countries in the Western Balkans Region and in the Mediterranean Basin.

Future works can elaborate downscaling of the method presented here to the local and metropolitan scale. This can lead to geospatial and statistical results for each smaller spatial unit to determine best future scenarios for a less fragmented territory at a gradient of spatial scales. The downscaling is crucial for better understanding the impact of LULC transformation on the ecosystem services provided by the interconnectivity of blue-green infrastructure at the metropolitan and urban scales (Deslauriers *et al*., 2019; Hysa, 2021).

CONCLUSIONS

This study presented a rapid and practical workflow for LF assessment at landscape scale. The study area consists of the territory of Albania. The raw data rely on various open source geospatial data providing information about the LULC, transportation network and geomorphology (DEM) of the study area. LF analysis is based on the effective mesh size (*meff*) landscape metric. Our results show that the natural landscapes in Albania face considerable levels of LF, refuting the report by European Environment Agency on LF at continent scale. The main causes are both anthropogenic (transportation network, urbanized areas, and agricultural lands) and natural (major rivers, lakes, alpine lands).

The method defines a hierarchical workflow of four stages. At each stage there are unique sets of fragmenting geometries which are expanding by additive elements like, main transportation routes, secondary roads, agricultural lands, and dominant natural features. According to our results, secondary road network and dominant natural elements have the highest impact in landscape fragmentation. Their capillary structure split the landscape patches into smaller patches and elevate the LF levels in Albania. Since Albania is a developing country where considerable investments in transportation network are still to come, it is vital that the decision-making bodies take in consideration the LF concerns while making new plans. This approach must be applied by other developing countries in the region of Western Balkans as they share unique trans-boundary eco-regions that holds values at continental scale.

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