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Landscape diversity in North Macedonia

Разновидност на предели во Северна Македонија

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Abstract:

This study provides data on landscape diversity in North Macedonia. Total of 41 landscape types have been identified, on a higher hierarchical level organised within 8 landscape groups. The character of natural landscapes is provided by relief, climate, geology, soils and vegetation cover set along elevation gradient. The character of cultural landscapes is withal provided by land use and settlement patterns with reference to landscape cultural specifics and historicity. Research outputs provide an opportunity to further address the importance of spatial configuration for ecological processes and hopes to serve as a methodological and conceptual guideline for succeeding national landscape classifications in the region.

Keywords: Landscape classification, valorisation, conservation, Balkans, Southeast Europe

Трудот обезбедува податоци за типот и карактеристиките на пределите во Република Северна Македонија. Идентификувани се вкупно 41 предел, на повисоко хиерархиско ниво организирани во 8 групи предели. Како појдовна основа за диференцијација на пределите земени се релјефот, климата, геологијата, почвата и вегетациската покривка поставени наспроти градиент на надморска височина. Дополнително, при идентификација на пределите земени се предвид и начините на користење на земјиштето, карактеристиките на населбите како и културните и историските специфики на пределите. Резултатите од истражувањето обезбедуваат основа за понатамошно адресирање на значењето на просторната конфигурација за еколошките процеси и ќе послужат како методолошки и концептуален водич при идните обиди за националните класификации на предели во регионот.

Клучни зборови: пределна класификација, валоризација, зачувување, Балкан, Југоисточна Европа

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Introduction

The long history of human settlement in Europe has resulted in an outstanding richness and diversity of landscapes (Meeus 1995; Mücher et al. 2010). Changes resulting from both socio-economic and environmental processes have affected the ecological, aesthetic and cultural-historical values of many of Europe's valued landscapes (Meeus et al. 1990; Hunziker et al. 2008; De Pablo et al. 2012). Following the Pan-European Biological and Landscape Diversity Strategy (Council of Europe 1996), the European Landscape Convention (Council of Europe 2000) has further drawn attention to the need for landscape preservation, committing the parties to account for their landscape diversity and to address the processes and effects of landscape change. Importance of landscapes for biodiversity is presently recognised in the worldwide biodiversity conservation efforts (Beresford and Phillips 2000). As nature conservation focus broadened to encompass landscape, conservation efforts aim towards an integrated action at a 'landscape scale' that allows for broader social, economic, and policy factors that are critical to sustainable livelihoods and ecosystems to be addressed more effectively.

On that note, the concept of landscape is being increasingly introduced in wide array of studies in the fields of ecology (Turner et al. 2001; Burel and Baudry 2003; Forman 2015; Wu 2017); ecosystem services (de Groot et al. 2010; Tengberg et al. 2012; Rodríguez-Loinaz et al. 2015); conservation (Opdam et al. 2003; Velázquez et al. 2019) and even population genetics (Balkenhol et al. 2015). While the focus of landscape research in Northern and Western Europe increases, relatively little attention has been given to the diverse and historically important Southeast European landscapes. However, following the states' commitments towards the aims of European Landscape Convention (Council of Europe, 2000) the awareness of the importance of landscape diversity and their characteristics is increasing.

Recent continuous interest of international donors and agencies boosted preparation of number of project reports (Melovski 2008a; b; c, 2010; Melovski et al. 2015) and publications (Melovski et al. 2010a) that dealt with typification of landscapes as part of implementation of various conservational programmes in North Macedonia. While landscape characterisation in most of these reports is descriptive, Melovski et al. (2015) build upon Melovski (2010) and provide comprehensive data on landscapes diversity including digital spatial data on identified landscape types and data on their structural-functional properties relative to their importance for conservation. A number of studies have raised the matter of land use/land cover changes and reflected on the importance of landscape composition and structure with regards to habitat connectivity and wildlife conservation. These data are presented in various thesis (Slavkovik 2011; Redzovik 2011), publications (Jovanovska and Melovski 2012; Despodovska et al. 2012; Jovanovska et al. 2017) and conference presentations (Avukatov et al. 2016). Later in 2016, in the frame of National Strategy for Nature Conservation of Republic of North Macedonia, Melovski et al. (2016) build upon the previous landscape assessments and identify and characterise the overall landscape diversity in the Country. The study provides insight into the importance of landscape type and configuration for biodiversity conservation with reference to the National Ecological Network (Brajanoska et al. 2011) ultimately aiming to contribute towards integral nature protection on a 'landscape scale'.

Considering the importance of these results as a background for implementation of other conservational and scientific projects in the country, and recognising the limited availability and robustness of project reports, the purpose of this paper is to provide an updated structured overview of results initially presented within the National Strategy for Nature Conservation of Republic of North Macedonia (Melovski et al. 2016). In detail, this paper aims to: (i) provide overview of the landscape diversity in North Macedonia on both local and regional scale; (ii) to provide landscape valorisation and identify the nationally most valuable landscapes (considering natural, conservational and cultural-historic value) and; (iii) to indicate the most relevant threats to landscape diversity in North Macedonia.

Research outputs provide an opportunity to further address the importance of spatial configuration for ecological processes over a large extent and will serve as a background for further studies aiming to assess landscape diversity in the region.

Methods

Republic of North Macedonia is a landlocked country in the central part of Balkan Peninsula, Southeast Europe. The country is characterised by high elevation gradient and high geodiversity. These attributes, complemented by the complexity of several variances of Mediterranean and Continental climate (Melovski et al. 2013) contributed towards the high diversity of ecosystems with distinctive organisation and distribution (Filipovski et al. 1996; MOEPP 2018). Throughout centuries, these natural ecosystems have been reshaped in accord with the culturally diverse background of the inhabitants and their accustomed practices. This has left a distinct human imprint on nature and led to formation of a specific landscape mosaic. Considering the complexity of factors contributing to landscape diversity in North Macedonia first step in landscape typification was to prioritise and organise the major factors according to their importance and contribution.

Landscape identification

The starting point in landscapes definition on a large scale is often climate (Meeus 1995; Mücher et al. 2010). Considering the relatively small area of North Macedonia, variation of climate as a standalone factor is insufficient (climate changes along the gradient of geographical latitude at much larger distances). Instead, the climate changes along the elevation gradient and it is significantly influenced by landform. The effect of relief and elevation on climate and vegetation, and consequently on the type and intensity of use of natural resources is prominent and therefore these criteria had a dominant role in differentiation of different landscape types. This approach led to formation of tabular matrix of differentiating criteria (Fig. 1, Tab. 1) for identifying and delineating landscape units:

1. **Elevation:** The main elevation belts relative to which defining landscape criteria are set in the matrix (column 1 in Tab. 1) were defined on the basis of distribution of vegetation zones (Matvejev and Puncer 1989; Lopatin and Matvejev 1995; Filipovski et al. 1996). Data layers obtained by georeferenced maps of biomes (Matvejev and Puncer 1989) and climate-vegetation-soil zones (Filipovski et al. 1996).
2. **Relief:** Relief has significant influence on land use and land cover; exposition (mainly northern and southern exposition of slopes) has an influence on climate and land cover or potential vegetation. Data layers include: digital elevation model (ASTER GDEM) and topographic maps in 1:25000 scale (Agency for Real Estate Cadaster of the Republic of Macedonia).
3. **Vegetation:** Vegetation types at higher level (dry grasslands, scrubs, forests, alpine pastures) with consideration of potential vegetation types. Associating key data sources: CORINE Land Cover 2018 and Sentinel-2 high resolution imagery; final classification and distribution of vegetation was determined on the basis of field specific data.
4. **Geology and soils:** Geological types were simplified, primarily based on their pH properties, into silicate rocks and carbonate rocks, then second generalisation was based on mineral composition and origin (e.g. serpentine, granite, gneiss) or formation type e.g. sedimentary. Soil types were also generalised (saline, clay, alluvial, brown mountainous soils, etc.). Geology data layer was based on georeferenced and digitised Geological Map of Macedonia in 1:100000 scale (Federal Geological Institute, Belgrade) and data on soil types were retrieved from MASIS (Soil Map of the Republic of Macedonia, Macedonian Soil Information System (MASIS), Ministry of Agriculture, Forestry and Water Economy of the Republic of Macedonia).
5. **Land use:** This criterion mainly reflects the type and intensity of land use (size and type of croplands, intensive versus extensive practices, presence of hedgerows etc.). Land use data was based on land use vector data (Agency for Real Estate Cadaster of the Republic of Macedonia) complemented by field specific data.
6. **Climate**: Climate, as an important attribute influencing vegetation patterns was considered with reference to climate and vegetation specifics along the elevation gradient i.e. climate-vegetation-soil zones (Filipovski et al. 1996) and with consideration of information provided in Lazarevski (1993)
7. **Naturalness**: No digital data layer

available. The naturalness of ecosystems was determined with consideration of history of use and accessibility of the natural resources.

8. **Settlements and cultural characteristics**: Specific digital data layer not available. Data on settlement properties e.g. type, character, population density were obtained by integrating land use/ land cover data layers and statistical data relating to the population at local and regional scale (State statistical office of the Republic of Macedonia 2012a); cultural characteristics were addressed with reference to specifics of use of land and natural resources particular for different ethnicities.
9. **History:** No digital data layer available. This criterion considers the processes of changes in land use in recent and distant past (for example, abandonment or intensification of agricultural activities). The assessment is based on expert judgement.

All criteria are set in matrix with reference to elevation belts and against individual criteria. Subject to the landscape identification criteria corresponding to the same elevation belt, the matrix allows distinction of more than one landscape type within one elevation belt. For example, areas within the lowland belt that differ with regards to other criteria (relief, vegetation, land use, geology and soils etc.) are differentiated as different landscape types (see Tab. 1). It is noteworthy that this methodological approach requires field experience and broader expert knowledge in landscape ecology.

Following Mücher et al. (2010) the landscape nomenclature is descriptive with reference to dominant landscape identification criteria: relief (flatland), climate (sub-Mediterranean-continental) dominant land cover class (agricultural) and land use specifics (rice fields) i.e. '*Flatland sub-Mediterranean-continental agricultural landscape of rice fields'*. If the landscape specifics are characteristic only for a particular area the landscape gets a name with a geographical determinant i.e. the example above would be '*Kochani landscape'*.

At the end, upon identification of landscape types following the above elaborated methodological approach, the identified landscape types were spatially defined in ArcGIS. In reality, boundaries between landscapes are diffuse, so defining clear boundary between different landscape types is rather artificial, but necessary for further analysis of their characteristics. In this case, the boundaries were determined by visual interpretation of the landscape identification criteria and on-screen digitisation (subjectively, mainly by observation of satellite imagery and partially by tracing features of available vector data). Generally, minimum landscape unit was set to 10 square kilometers, as minimum area that can be visually recognised by human eye as "uniform" (considering the heterogeneity within). Exclusions to his rule were made in case of areas where, despite the surface, the intensity and the specifics of land use strongly contrast the structural (and functional) characteristics of the surroundings and the area is visually assertive to the observer.

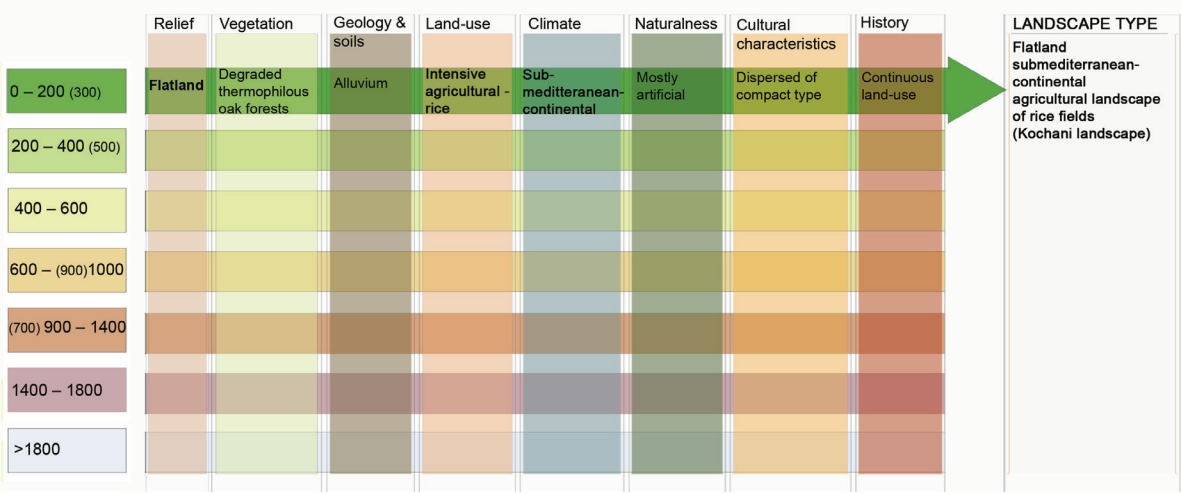

Fig. 1. Graphical presentation of the tabular matrix of differentiating criteria for identification of landscape types

Landscape valorisation

Landscape valorisation aims at determining the importance of a particular landscape or landscape specific by referring to specified value criteria. Valuation criteria vary depending on the purpose for valorisation. In this study, landscapes are valued mainly from the aspect of their functional value for the conservation of biodiversity. In addition, here we attribute value with reference to cultural values of landscapes, uniqueness of the landscape and the visual landscape quality.

Valorisation criteria:

- ***Landscape character***. It refers to the distinctive and recognizable pattern of features that characterise the specific landscape type (Lausch et al. 2015). This criterion is applied when comparing two landscape units of the same type.
- ***Landscape condition***. The criterion is related to landscape character and indicates the representability of the pattern of landscape features that characterise the landscape type (Bertollo 2001). The criterion allows comparison of landscape units within landscape type, but also comparison between different landscapes types.
- ***Landscape natural and cultural values***. It refers to the aspects attributing importance to a given landscape type with reference to both its natural and cultural values. Landscape can be characterised as important for conservation due to its value for biodiversity conservation (Opdam et al. 2003), possession of exceptional scenic values (Fry et al. 2009; Ramos and Pastor 2012; Frank et al. 2013; Swetnam et al. 2017) or possession of important cultural or historical features (Brabec 2010; Tengberg et al. 2012). The criterion allows comparison of landscape units within landscape type, but also comparison between different landscapes types.
- ***Landscape sensitivity***. This criterion is related to landscape condition and indicates the landscape integrity i.e. landscape capacity to endure change without undergoing significant alteration of the basic features that define the landscape character (Usher 2001). While assessing landscape sensitivity present threats were also considered. This criterion allows comparison of landscape units within landscape type, but also comparison between different landscapes types.
- ***Connectivity of resource patches in the landscape***. Connectivity denotes connectedness and connectivity of the resource patches in the landscape. It may also refer to connectivity of individual landscape units or individual landscapes within wider area. Landscape connectivity can be defined as the degree to which the landscape facilitates or impedes movement between resources patches (Taylor et al. 1993; Bennett et al. 2003). Landscape connectedness plays an important role in dispersal of species, and consequently in biodiversity conservation (Harrison and Fahrig 1995; Velázquez et al. 2019). The criterion allows comparison of landscape units within landscape type, but also comparison between different landscapes types.
- ***Landscape uniqueness***. Even though there is no specific literature on this criteria, we consider this complementary criteria significant in identifying landscape types that are important for conservation on a national level. It refers to the area coverage of a particular landscape type in North Macedonia, that is, the area occupancy and frequency of occurrence of landscape units from a specific landscape type. Limited area coverage and low frequency of occurrence means higher landscape sensitivity and higher probability of loss of landscape specifics. The criterion allows comparison of landscape units within landscape type, but also comparison between different landscapes types.

Landscapes are valorised by assigning a value of 0 to 3 points for each criterion with reference to each landscape type. In this case, 0 indicates that the landscape has no value for the given criterion, while 3 denotes a very high value.

Tab. 1. Matrix for identification and characterisation of landscapes

Elevation	Relief (Slope, exposition)	Vegetation (Land cover)	Geology and soils	Land use	Climate	Naturalness	Settlements and cultural characteristics	History	Landscape type	Landscape type (in Macedonian)
									Link to landscape group indicated in bold	
1. Lowlands up to 200 (300) m	Flatland with mild slopes	Sclerophyllous vegetation (Pseudomaquis), mostly absent	Alluvium, colluvium	Intensive - early garden vegetables, vineyards	Sub-Mediterranean	Mostly artificial	Numerous, of compact type	Continuous land use	Flatland sub-Mediterranean **agricultural** landscape	Рамничарски субмедитерански **земјоделски** предел
	Mild slopes, flatland	Lake surface; Pseudomaquis; or absent	Colluvium, wetland-gley soils	Intensive - olive trees, vineyards; mixed crops			Few, of compact type; tourist objects		Sub-Mediterranean **lake landscape** (Dojran landscape)	Субмедитерански **езерски предел** (Дојрански предел)
	Rolling-hilly	Pseudomaquis	Silicate rocks, rarely carbonate	Scrubland, grazing		Semi-natural	Few, of compact type	Abandonment, encroachment	Rolling sub-Mediterranean landscape of sclerophyllous scrub (Pseudomaquis landscape) -> **Forest landscape**	Бреговит субмедитерански предел на склерофилни грмушки (Предел на псевдомакија) -> **Шумски предел**
1. Lowlands, up to 200-400 (500) m	Flatland and/or mild slopes	Absent or narrow corridors of riparian forests; fragments of thermophilous oak forests	Alluvium, gley soils	Intensive – rice fields	Sub-Mediterranean influence	Mostly artificial	Dispersed, not dense, of compact type	Continuous land use	Flatland sub-Mediterranean-continental **agricultural** landscape of rice fields (Kochani landscape)	Рамничарски субмедитеранско-континентален **земјоделски** предел на оризови полиња (Кочански предел)
			Alluvium or marl, saline soils	Intensive – wheat cultures					Flatland sub-Mediterranean-continental **agricultural** landscape on saline soils (Ovche Pole flatland landscape)	Рамничарски субмедитеранско-континентален **земјоделски** предел на солени почви (Овчеполски рамничарски предел)
			Alluvium	Intensive - vineyards					Flatland-rolling sub-Mediterranean-continental **agricultural** landscape of vineyards (Tikvesh landscape)	Рамничарско-бреговит субмедитеранско-континентален **земјоделски** предел на лоза (Тиквешки предел)
				Intensive-diverse cultures			Dense, of compact type		Flatland sub-Mediterranean-continental **agricultural** landscape-typical	Рамничарски субмедитеранско-континентален **земјоделски** предел – типичен облик
		Absent; Parks and urban green areas	Artificial; Concrete	Construction land		Artificial	Cities	Progressive urbanisation	**Urban** landscape	**Урбан** предел
2. Lowlands, 400-600 m	Hilly; mild slopes; valleys with steep slopes	Absent or almost absent	Alluvial terraces	Intensive-wheat and mixed culture; urban area	Sub-mediterranean influence to warm continental	Mostly artificial	Dispersed, not dense, of compact type	Continuous land use	Rolling sub-Mediterranean-continental agricultural landscape (Rolling **agricultural** landscape)	Бреговит субмедитеранско-континентален земјоделски предел (Бреговит **земјоделски** предел)
		Small fragments		Extensive-mixed cultures		Mixed		Evidence of abandonment	Rolling sub-Mediterranean-continental **agricultural**-rural landscape (Rolling agricultural-rural landscape)	Бреговит субмедитеранско-континентален **земјоделско**-рурален предел (Бреговит земјоделско-рурален предел)
		Absent		Industrial		Artificial	Absent	Intensive use of resources; Land transformation	**Industrial-mining** landscape	**Индустустриско-руднички** предел
		Fragments of oak forests		Extensive agriculture		Highly modified	Numerous dense villages of compact type; small field parcels	Weak evidence of abandonment	Rolling sub-Mediterranean-continental rural landscape (Rolling **rural** landscape)	Бреговит субмедитеранско-континентален рурален предел (Бреговит **рурален** предел)
							Dense villages of compact type; small field parcels with hedges		Rolling sub-Mediterranean-continental rural landscape with hedgerows (Rolling **rural** landscape with hedgerows)	Бреговит субмедитеранско-континентален рурален предел со меѓи (Бреговит **рурален** предел со меѓи)
3. Low elevation belt 600-900 (1000)	Flatland	Fragments of riparian and oak forests	Alluvium	Intensive agriculture	Warm continental	Mostly artificial	Dense of compact type - large	Continuous land use, urbanisation	Flatland sub-continental **agricultural**-rural landscape of mixed cultivation pattern (Polog landscape)	Рамничарски субконтинентален **земјоделско**-рурален предел на мешани култури (Полошки предел)

Elevation	Relief (Slope, exposition)	Vegetation (Land cover)	Geology and soils	Land use	Climate	Naturalness	Settlements and cultural characteristics	History	Landscape type	Landscape type (in Macedonian)
									Link to landscape group indicated in bold	
		Almost absent			Warm continental with partial weak mediterranen influence			Continuous intensive land use	Flatland sub-continental **agricultural** landscape of wheat cultures (Pelagonia landscape)	Рамничарски субконтинтален **земјоделски** предел на житни култури (Пелагониски предел)
	Flatland and rolling with mild slopes	Absent or almost absent	Sediments and slit - silicate	Semi-intensive agriculture			Villages of compact type and small cities	Continuous land use; evidence of abandonment	Flatland-rolling continental rural-**agricultural** landscape (Maleshevo-Pijanec landscape)	Рамничарско-брегови континентален рурално-**земјоделски** предел (Малешевско-пијанечки предел)
			Alluvium, sediments and slit	Semi-intensive and extensive agriculture					Flatland-rolling sub-continental **agricultural**-rural landscape	Рамничарско-брегови субконтинентален **земјоделско**-рурален предел
		Lake surface; absence of natural vegetation	Lake sediments	Intensive agriculture, mixed cultures; intensive tourism	Warm continental to continental with Mediterranean influence	Artificial, except the lake	Cities, villages of compact type; Tourist objects	Continuous land use	Sub-Mediterranean-continental **lake** landscape (Ohrid landscape)	Субмедитеранско-континентален **езерски** предел (Охридски предел)
		Lake surface; fragments of oak forests and wetlands		Intensive agriculture-orchards; tourism	Modified warm continental to continental	Mostly artificial, except the lake	Villages of compact type and small cities, few tourist objects		Sub-continental **lake** landscape (Prespa landscape)	Субконтинентален **езерски предел** (Преспански предел)
	Rolling-hilly; deep gorges	Fragments of oak forests; hilly pastures	Granite, sometimes carbonate	Pastures; scrubland; extensive agriculture	Warm continental with Mediterranean influence	Semi-natural	Abandoned villages	Notable abandonment; advanced encroachment	Hilly sub-Mediterranean-continental **rural** landscape with dry grasslands (Mariovo landscape)	Ридест субмедитеранско-континентален **рурален** предел со брдски пасишта (Мариовски предел)
	Hilly, steep and mild slopes, deep valleys	Fragments of oak forests	Mostly silicate ground	Extensive agricultures	Warm continental with weak Mediterranean influence	Highly modified	Numerous dense villages of compact type; small field parcels	Weak evidence of abandonment	Hilly sub-continental **rural** landscape (Hilly rural landscape)	Ридест субконтинентален **рурален** предел (Ридест рурален предел)
		Fragments of oak forests; scrubland	Carbonate	Livestock breeding		Semi-natural	Sparse villages of compact type	Abandonment	Hilly sub-continental **dry grassland landscape** on limestone ground (Dry grassland landscape on limestone ground)	Ридски субконтинентален **предел на брдски пасишта** на варовничка подлога (Предел на брдски пасишта на варовничка подлога)
			Serpentine ground						Hilly sub-Mediterranean-continental **dry grassland landscape** on serpentine ground (Dry grassland landscape on serpentine ground)	Ридски субмедитеранско-контиентален **предел на брдски пасишта** на серпентинит (Предел на брдски пасишта на серпентинити)
			Granite rocks and rocky ground						Hilly sub-continental **dry grassland landscape** on granite ground (Treskavec landscape)	Ридски субконтиентален **предел на брдски пасишта** на гранитни каменьари (Трескавечки педел)
			Silicate ground	Livestock breeding					Hilly sub-continental **dry grassland landscape** on silicate ground (Dry grassland landscape on silicate ground)	Ридски субконтинентален **предел на брдски пасишта** на силикатна подлога (Предел на брдски пасишта на силикатна подлога)
			Marl ground				Numerous sparse villages of compact type, abandoned		Hilly-rolling sub-Mediterranean-continental **dry grassland landscape** on marl ground (Dry grassland landscape on marl ground)	Ридско-брегови субмедитеранско-континентален **предел на брдски пасишта** на лапореста подлога (Предел на брдски пасишта на лапореста подлога)
4. Medium elevation belt (700) 900-1400 m	Hilly-mountainous; steep and mild slopes, deep valleys	Xerothermophilous degraded oak forests	Silicate ground	Forestry	Warm continental	Semi-natural	Absence of settlements	Abandonment	Hilly sub-Mediterranean-continental degraded Thermophilous **forest landscape** (Thermophilous degraded forests landscape)	Ридски субмедитеранско-континентален предел на термофилни деградирани шуми (Предел на термофилни деградирани **шуми**)
		Thermophilous and Mesophilous oak forests; pine plantations		Forestry		Forest plantations	Absence of settlements or scarce settlements	Active management and land use	Hilly-mountainous sub-continental broadleaf **forest landscape** with conifer stands (Broadleaf forest landscape with conifer stands)	Ридско-планински субконтинентален предел на мешани шуми со иглолисни насади (Предел на мешани **шуми** со иглолисни насади)
		Thermophilous and Mesophilous		Very extensive agriculture, forestry		Modified forests – fragments	Dispersed – of scattered type, numerous	Abandonment	Mountain continental rural-forest landscape (Osogovo mountain **rural** landscape or Osogovo landscape)	Планински континентален рурално-шумски предел (Осоговски планински

Elevation	Relief (Slope, exposition)	Vegetation (Land cover)	Geology and soils	Land use	Climate	Naturalness	Settlements and cultural characteristics	History	Landscape type	Landscape type (in Macedonian)
									Link to landscape group indicated in bold	
		oak and beech forests					settlements "maala" comprise one village			**рурален** предел или Осоговски предел)
			Diverse geology				Separate objects	Dominant presence of extensive agriculture/notable abandonment	Mountain continental **rural**-agricultural landscape (Maleshevo mountain rural landscape)	Планински континентален **рурален**-земјоделски предел (Малешевски планински рурален предел)
								Extensive agriculture and abandonment	Mountain continental **rural** landscape	Планински континентален **рурален** предел
							Cultural specifics of inhabitants	Continuous land use; Conservational activities	Reka mountain continental **rural** landscape	Реканski планински континентален **рурален** предел (Реканski предел)
5. High mountain belt (1400-1800 m)	Mountainous; steep and mild slopes, deep valleys	Beech and sessile oak forests		Forestry	Continental to mountainous	Semi-natural to natural	Dispersed villages of compact type, tourist settlement		Mavrovo mountain continental **rural** landscape	Мавровски планински континентален **рурален** предел (Мавровски предел)
									Mountain continental mesophilous broadleaf **forest landscape** (Mesophilous broadleaf forest landscape)	Планински континентален предел на мезофилни широколисни **шуми** (Предел на мезофилни широколисни шуми)
		Black and Scots pine forests and mixed forests					Absence of settlements		Mountain sub-continental-continental pine **forest landscape** (Pine forest landscape)	Планински субконтинентално-континентален предел на борови **шуми** (Предел на борови шуми)
		Fir, spruce and mixed forests with beech							Mountain continental spruce-fir **forest landscape** (Spruce-fir forest landscape)	Планински континентален предел на елово-смрчови шуми (Предел на елово-смрчови **шуми**)
6. Subalpine and alpine zone (>1800 m)	Mountainous; mostly mild slopes and shallow valleys	Coniferous scrubs	Silicate and carbonate	Insignificant	Mountainous	Semi-natural, natural	Absence of settlements; scarce sheepfolds	Stable	Mountain mugo pine scrub landscape (Mugo pine landscape) -> **Forest landscape**	Планински предел на кривоборови шибјаци (Предел на кривоборови шибјаци) -> **Шумски предел**
		Subalpine pastures, heathlands and peatlands	Silicate and carbonate	Livestock breeding, recreation				Continuous use with evidence of abandonment	**Mountain grasslands landscape** on limestone ground	**Планински предел на пасишта** на карбонатна подлога (Предел на планински пасишта на карбонатна подлога)
			Silicate	Livestock breeding, berry collection, recreation					**Mountain grasslands landscape** on silicate ground	**Планински предел на пасишта** на силикатна подлога (Предел на планински пасишта на силикатна подлога)
	Alpine; steep slopes and diffs	Subalpine pastures, heathlands, rocks and screes	Carbonate	Livestock breeding, recreation, wilderness	Mountainous	Natural	Absent	Continuous absence of land use	Highmountain landscape of silicate rocks and rocky ground (**Landscape of** silicate **rocky ground**)	Високопланински предел на силикатни карпи и камењари (**Предел на** силикатни **карпи и камењари**)
			Silicate						Highmountain landscape of limestone rocks and rocky ground (**Landscape of** limestone **rocky ground**)	Високопланински предел на карбонатни карпи и камењари (**Предел на** карбонатни **карпи и камењари**)

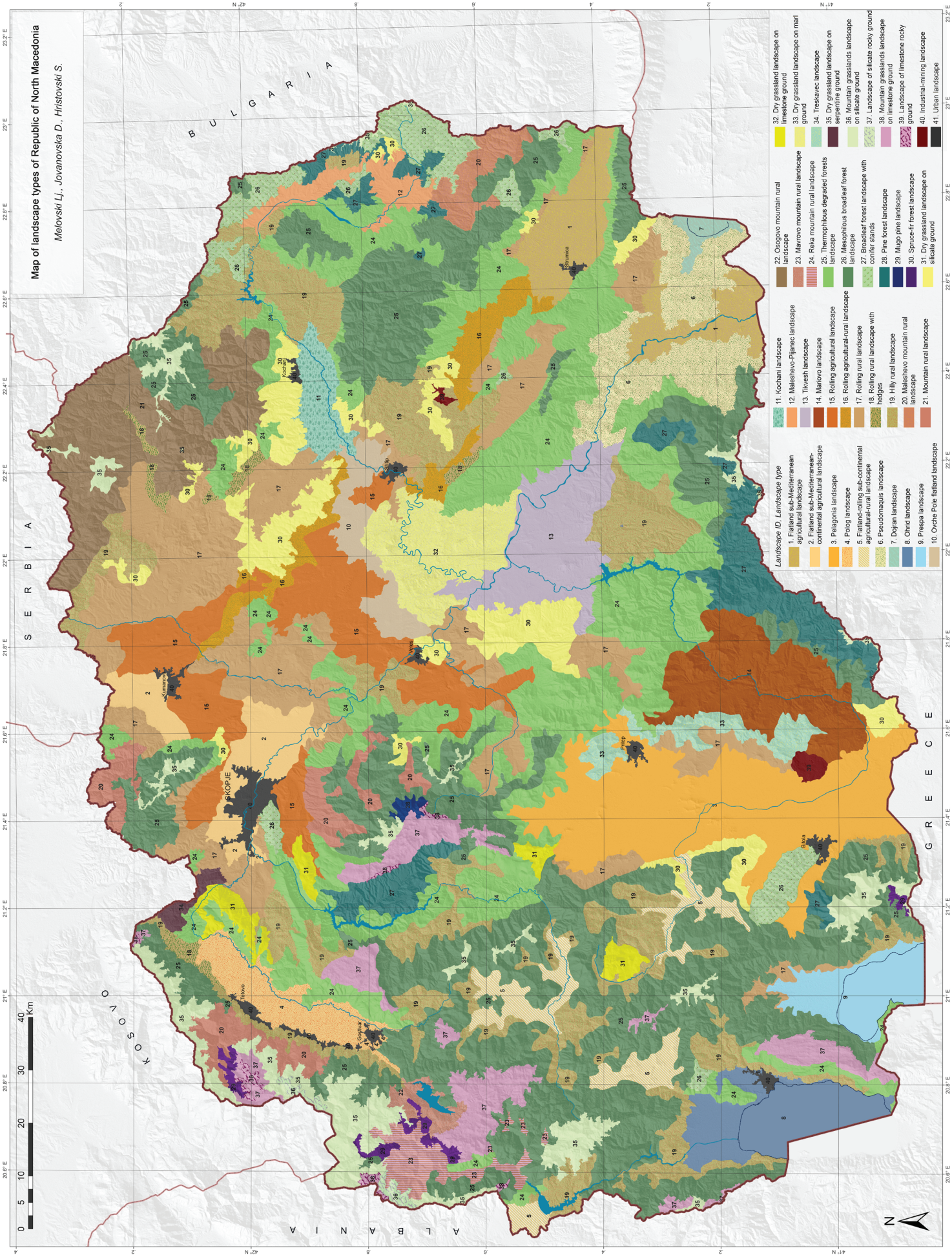

Fig. 2. Map of identified landscape types in North Macedonia.

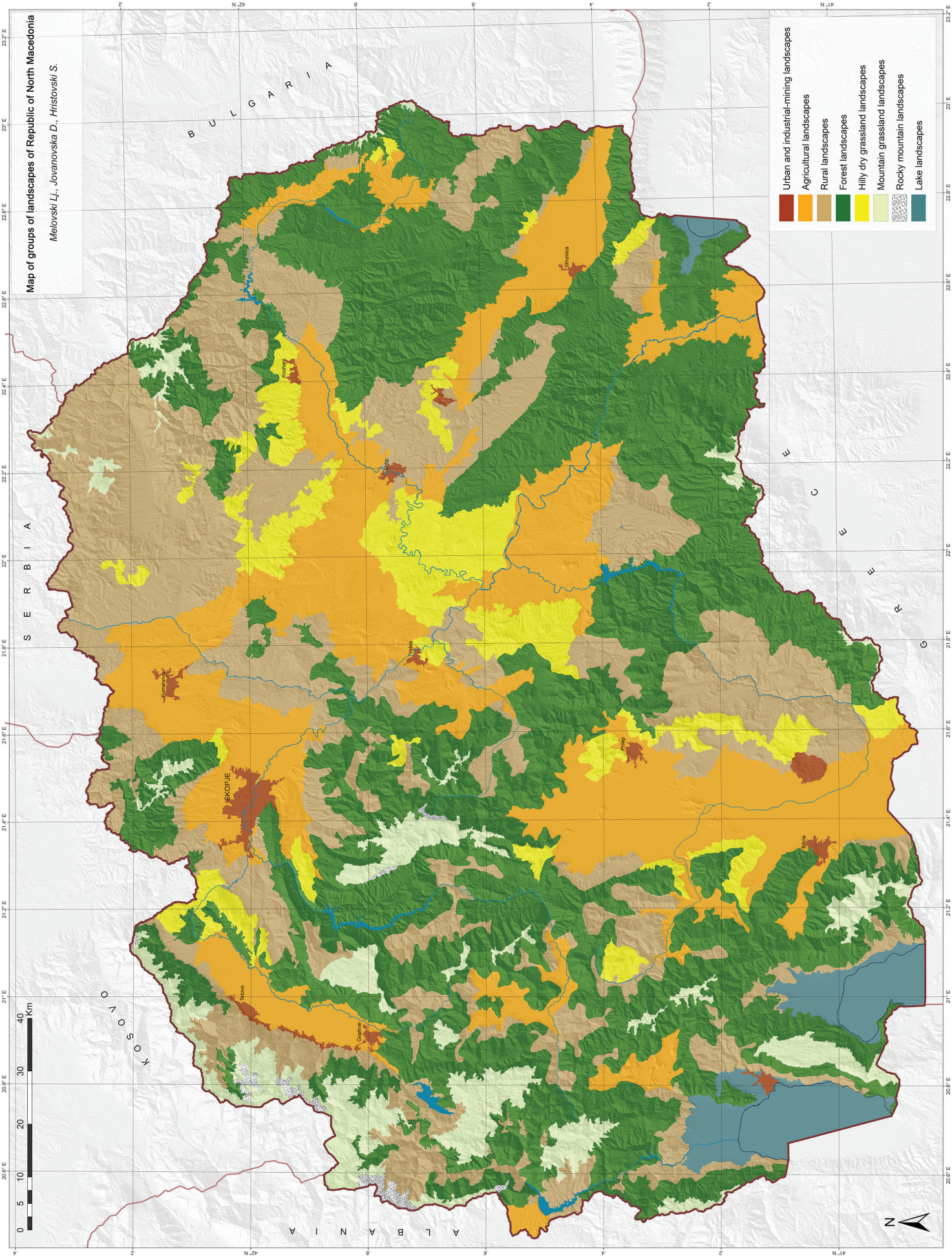

Fig. 3. Map of groups of landscape types i.e. landscape groups

Results

Landscape diversity

The landscape diversity in North Macedonia is presented with total of 41 landscape types (Tab. 1, Fig. 2) organised within 8 landscape groups (Fig. 3): Urban and industrial-mining landscapes; Agricultural landscapes, Rural landscapes, Hilly dry grasslands landscape, Forest landscapes, Mountain grasslands landscapes, Mountain rocky landscapes and Lake landscapes.

Due to the specific climatic and biogeographic characteristics along the elevation gradient and due to the specifics and the intensity of land use, all landscape types have specific structural and functional properties. Also, there is a notable difference between separate landscape units within the identified landscape types. However, considering the scope of this study we only elaborate the specifics of landscape groups with reference to the general specifics of landscape types within.

Urban and Industrial-mining landscapes

The 'Urban landscape', in its typical form, is representative only for City of Skopje (Fig. 2, code 41). Being the largest urban conglomerate in the country Skopje hosts more then 1/4 (State statistical office of the Republic of Macedonia 2002) of the total population of the country and its urban area continuously expands. In terms of internal migration processes, Skopje has the largest immigration rate in the country (State statistical office of the Republic of Macedonia 2012b). This study identifies as urban few other major towns/cities in the country that occupy smaller area (6-14 km^2) but have notable urban features. Such cities are Kumanovo, Bitola, Ohrid, Tetovo, Shtip, Prilep, Gostivar, Kocani, Veles and Strumica. Compared with the City of Skopje, the number of inhabitants in all other cities characterised as urban goes up to 1/3 of the total population of the country (State statistical office of the Republic of Macedonia 2002).

Despite the recent governmental initiatives of promoting the use of mineral resources, North Macedonia is not considered as industrially developed country and thus areas with typical industrial setting are scarce while most of the mines are underground. Within the scope of this study, only the coal mine in village Novaci together with the energy complex "REK Bitola" (near 30 km^2) can be separated as a separate 'Industrial-mining landscape' unit. This study also identifies mine "Buchim", as 'Industrial-mining landscape' unit with typical industrial mining features (Fig. 2, code 40). Despite its small surface, the intensity of land use strongly contrasts with the natural specifics of its surroundings and being an open pit mine, the complex is visually assertive to the observer.

Both landscape types differ in terms of their specifics but are essentially artificial in character. In terms of composition, both landscape types are dominated by man-

Tab. 2. Basic structural characteristics (composition) of 'Industrial-mining landscapes' group

Land cover class	Area (ha)	Area (%)
Discontinuous urban fabric	13461	62%
Industrial or commercial units	2443	11%
Pastures	1549	7%
Mineral extraction sites	1343	6%
Complex cultivation patterns	762	4%
Dump sites	554	3%
Land principally occupied by agriculture, with significant areas of natural vegetation	440	2%
Green urban areas	335	2%
Continuous urban fabric	202	1%
Transitional woodland-scrub	186	1%
Non-irrigated arable land	169	1%
Other	316	2%
Total	**21759**	

modified (constructed, industrial) and other artificial habitats and habitat complexes (Tab. 2). The structural arrangement of landscape elements is heavily managed, structured, designed and engineered.

Considering the prevalent area of 'Urban landscapes' (182 km^2) over the 'Industrial-mining landscape' (35 km^2), the composition of this landscape group is determined by the dominant participation of the land cover classes' characteristic for the urban landscapes: *Discontinuous urban area* and *Industrial or commercial units* meaning the matrix in the 'Urban landscape' is represented by residential and other facilities. The composition of the 'Industrial-mining landscapes' is determined by the participation of land cover classes of *Mineral extraction sites* and *Dump sites* with notable presence of *Pastures* reflecting the landscape composition matrix prior to the anthropogenic activities.

Corridors are mostly presented by lines of trees along asphalt roads. Smaller patches of broadleaved tree stands are characteristic for the urban parks or for the residential settlements in the peripheral urban areas (houses with gardens, fields and meadows). River corridors in the urban areas are significantly altered in terms of hydromorphology (river bed regulation), but also with reference to structure and functionality of the riparian corridors (Jovanovska et al. 2013). Vegetation is typically ruderal, mostly represented by perennials (weed communities and cultivated plants) and shrubs. Species diversity is generally low with dominant presence of anthropohore species that have high abundance. Higher diversity (especially birds) is found in remnant patches of natural vegetation and urban parks, as is the case with City Park in Skopje.

Agricultural landscapes

Agricultural landscapes occupy 20% of the total area of North Macedonia and are represented by 11 landscape types (Tab. 1, Fig. 2, Fig. 3). Agricultural landscapes mainly span in the area of broad plains, floodplains and valleys on an average elevation that spans from 170 m ('Flatland sub-Mediterranean agricultural landscape'; see Fig. 2, code 1) to 810 m ('Maleshevo-Pijanec landscape'; see Fig. 2, code 12). The relief is mostly level or nearly level, somewhat rolling with mild slopes and river dales. Climate is sub-Mediterranean to warm Continental with Mediterranean influence. The specific natural and geographic characteristics (geomorphology, pedological and hydrographic features and climate) in different areas have favored some agricultures over others, thus contributing to formation of agriculture specific landscape types with recognising visual attributes (e.g. wheat cultures on saline ground are representative for 'Ovche Pole flatland landscape' (Fig. 2, code 10), vineyards are specific for 'Tikvesh landscape' (Fig. 2, code 13) etc.). Anthropogenic activities in the country have been targeted at modification of natural vegetation towards agricultural expansion for centuries. Yet, fragmentation and alteration

Tab. 3. Basic structural characteristics (composition) of 'Agricultural landscapes' group

Land cover class	**Area (ha)**	**Area (%)**
Non-irrigated arable land	213028	41%
Complex cultivation patterns	119440	23%
Land principally occupied by agriculture, with significant areas of natural vegetation	49380	10%
Pastures	26358	5%
Permanently irrigated land	25529	5%
Vineyards	24749	5%
Discontinuous urban fabric	15140	3%
Transitional woodland-scrub	13355	3%
Broad-leaved forest	7924	2%
Rice fields	6403	1%
Other	12448	2%
Total	**513754**	

of natural habitats (swamps, marshes, humid meadows and riparian woodlands) was most intensive during the second half of the XX century. In the past decades, the land transformation has changed in character in many of the identified agricultural landscape types. Due to abandonment of agricultural practices, agricultural land is left fallow or is being transformed to urban and semi-urban contributing to loss of landscape specifics.

Today, the main feature of agricultural landscapes is intensively cultivated agricultural land (unlike rural landscapes where heterogeneous extensive agriculture is predominant) (Fig. 4 and Fig. 5).

The composition of this landscape group is determined by the dominant participation of the land cover classes typically representative for agricultural landscapes (Tab. 3): *Non-irrigated arable land*, *Complex cultivation patterns* and *Land principally occupied by agriculture, with significant areas of natural vegetation*.

The matrix is largely represented by large areas under arable land - fields and croplands with cereal crops. In addition to these, there are also large areas under vineyards, planted on heterogeneous, smaller in size croplands and fields. The matrix of agricultural lands hosts high number of villages of compact type.

Patches of natural vegetation are mostly sparse and represented by small plots of anthropogenic tree stands, minor remains of Pubescent oak and hornbeam forests, xerothermic shrubs and grasslands. There are also patches of small or larger marshy areas. Pastures are significant component of this landscape from biodiversity point of view. Corridor presence and importance increases with decrease in intensity of agricultural land use and depends on agricultural landscape types setting with reference to other landscape types. Generally, landscape types within this group don't have significant contribution to wild species conservation but host secondary anthropogenic habitats which are significant for the preservation of biodiversity in contemporary environment.

Rural landscapes

Rural landscapes occupy 25% of the total area of North Macedonia and are represented by 9 landscape types (Tab. 1, Fig. 2, Fig. 3). The diversity of rural landscapes reflects the diversity of human practices accommodated to the availability (or scarcity) of resources

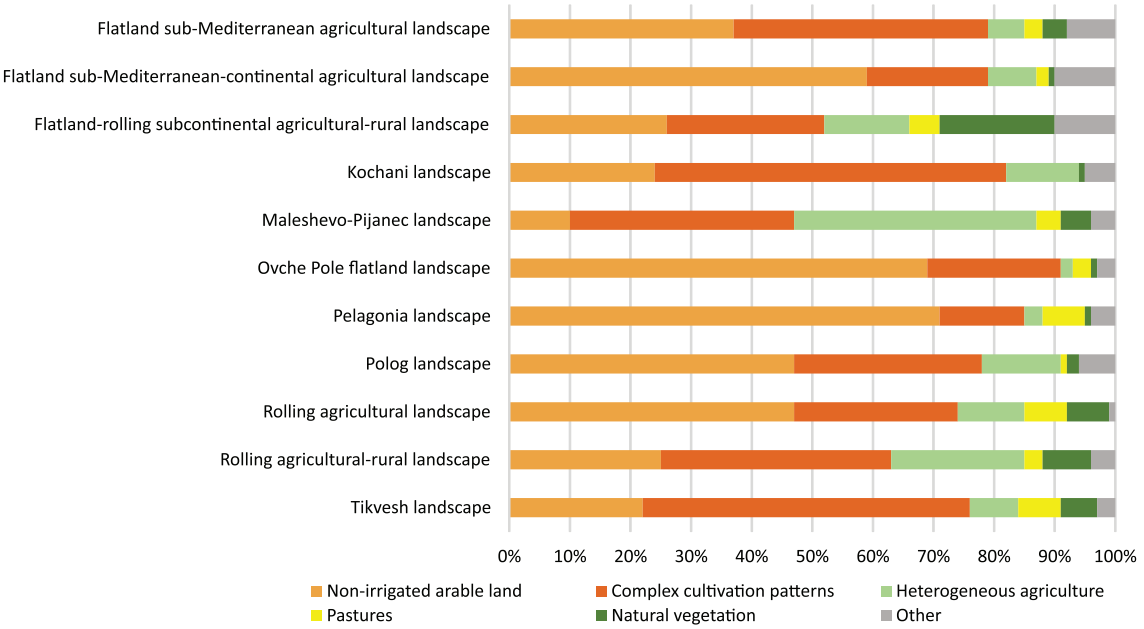

Fig. 4. Overview of land cover class participation in 'Agricultural landscapes' composition by landscape type

Note: For the purpose of this graph *Complex cultivation patterns* includes *Vineyards* and *Fruit trees and berry plantations*; *Heterogeneous agriculture* stands for *Land principally occupied by agriculture, with significant areas of natural vegetation*.

Tab. 4. Basic structural characteristics (composition) of 'Rural landscapes' group

Land cover class	Area (ha)	Area (%)
Broad-leaved forest	150696	24%
Transitional woodland-scrub	139448	22%
Land principally occupied by agriculture, with significant areas of natural vegetation	105665	16%
Pastures	94021	15%
Complex cultivation patterns	71790	11%
Natural grassland	28763	4%
Non-irrigated arable land	21877	3%
Mixed forest	7625	1%
Coniferous forest	6463	1%
Discontinuous urban fabric	2843	<1%
Other	11581	2%
Total	**640772**	

along an environmental gradient. The specific arrangement of vegetation types along the elevation gradient and the diverse ethnical and cultural background of the inhabitants and their accustomed practices bent by past and present socio-economic policies in North Macedonia have contributed to high diversity of rural landscapes. For this reason, landscape types within this group differ in terms of character, composition and arrangement of landscape elements and distinctions are notable even between landscape units within landscape type.

Rural landscapes in North Macedonia are predominantly presented by the type 'Hilly rural landscapes' (33%) (42 % with 'Mariovo landscape' included), then 'Rolling rural landscape' (32%) (34% with 'Rolling rural landscape with hedges included'), while the highest diversity of landscape types is found within mountain rural landscapes (24%). Even though mountain rural landscapes individually occupy small surface, due to the isolating effect of the mountainous relief and the environmental and land use specifics, all mountain rural landscapes have distinctive character. On a fine scale, separate landscape types with location specifics may be delineated within the mountain rural landscape type e.g. 'Shar Planina mountain rural landscape'.

Rural landscapes are distributed mainly in the hilly areas and mountain slopes on an average elevation that ranges from 520 m ('Rolling rural landscape'; see Fig. 2, code 17) to 1390 m ('Mavrovo mountain rural landscape'; see Fig. 2, code 23). The relief is mostly intermediately to moderately rugged, somewhat rolling with mild slopes and river dales or mountainous with steep slopes and deep valleys. Climate is generally warm Continental with Mediterranean influence with reference to rolling rural landscapes and hilly rural landscapes) and Continental to Mountainous (with reference to mountain rural landscapes). Though anthropogenic in character, in rural landscapes the human impact on the landscape character is visible but still extensive allowing rural landscapes to serve as a link between anthropogenic and "natural" landscapes. The main feature of rural landscapes are extensive land management practices reflected by the small-scaled heterogeneous agriculture (fields and meadows) most often distributed discontinuously in the area. Livestock breeding also has an important role in determining the character of rural landscapes. Due to the abandonment of traditional land use practices instigated by the rural-urban migration, large portion of rural landscapes is affected by the ongoing natural succession especially notable in encroachment of meadows and grasslands while large portion of villages are being transformed to tourist settlements or abandoned. This transformation contributes to loss of landscape specifics and can ultimately lead to decline in diversity of rural landscapes.

The rural character of the landscape is attributed by the participation of the land cover classes: *Land principally occupied by agriculture, with significant areas of natural vegetation, Complex cultivation patterns* (Tab. 4). Natural vegetation, mainly represented by *Transitional woodland-scrub, Pastures* and *Broad-leaved forests* has significant share in the composition of rural land-

scapes. At this scale, there is no single land cover class to characterise the matrix of rural landscapes. Instead, all dominant classes of land cover intercept to form patched mosaic that represents the matrix.

Patches of natural vegetation are represented by xerothermic shrubs and grasslands, oak forests (up to 900 m a.s.l.) and beech forests higher up (beech forests also occur in ravines and occupy the northern slopes at lower elevations). Going from rolling/hilly rural landscapes (Fig. 2, code 14 and codes 17-19) to mountain rural landscapes (Fig. 2, codes 20-24) the area of heterogeneous agriculture generally declines as natural vegetation increases its dominance in the character of rural landscapes (Fig. 5). Corridor presence and importance also increases going from rolling/hilly rural to mountain rural landscape types. The high share of natural vegetation in combination with the extensive land use practices allows rural landscapes to serve as a supporting habitat for small mammals and serve as corridors for large carnivore species inhabiting the neighboring forest landscapes.

Hilly dry grasslands landscape

Hilly dry grasslands landscapes occupy only 7% of the total area of North Macedonia and are represented by 5 landscape types (Tab. 1, Fig. 2, Fig. 3). The 'Dry grassland landscape on silicate ground' dominates over other landscape types within this group and occupies 50% of the total area under Hilly dry grasslands landscapes.

Pastures in the hilly part of Macedonia are secondary formation resulting from continued cattle breeding and grazing initiated thousands of years ago. However, once strong anthropogenic pressure that historically contributed to the shaping and formation of areas under pastures has lessened in intensity. Negative migration trend of the population (State statistical office of the Republic of Macedonia 2012b), combined with significant neglect of cattle breading practices lead to gradual abandonment of areas used as pasture and this in turn leads to successive overgrowth with shrubs and loss of the basic structural feature of the landscapes of dry grasslands – open pastures. Maintaining this type of landscape should be a challenge for future generations of socio-economic and politic stakeholders.

Hilly dry grasslands landscapes are distributed on an average elevation range from 350 m a.s.l. (in the case of 'Dry grassland landscape on silicate ground'; see Fig. 2, code 31) to 960 m a.s.l. (in the case of 'Dry grassland landscape on limestone ground'; see Fig. 2, code 32). The relief is predominantly hilly with

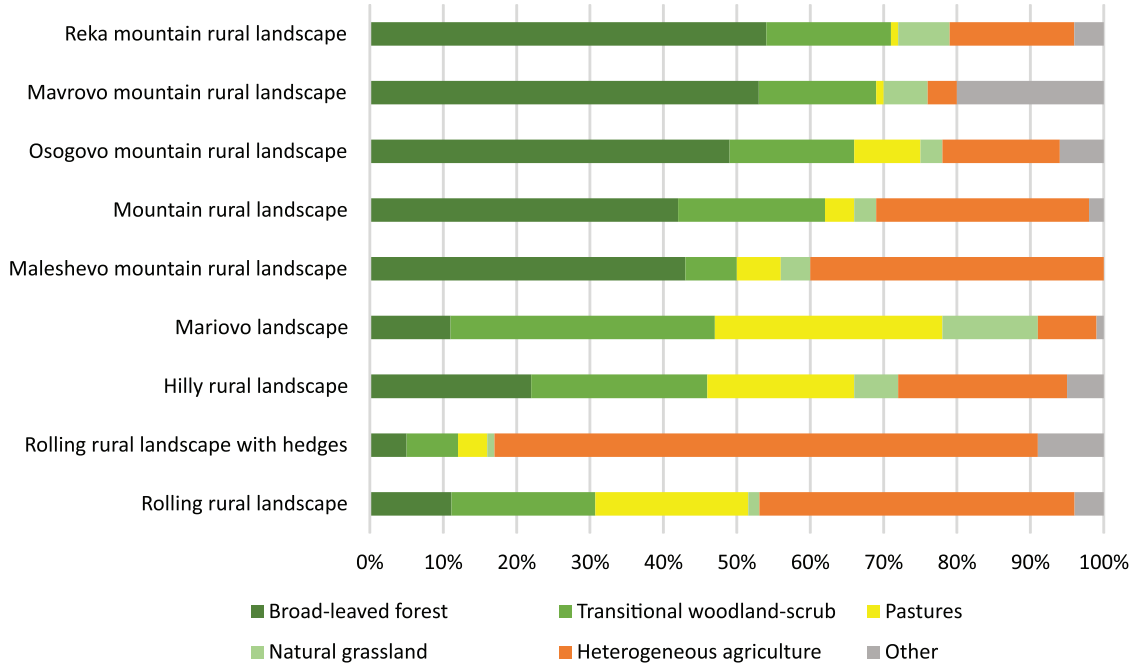

Fig. 5. Overview of land cover class participation in 'Rural landscapes' composition by landscape type. See note on Fig. 4.

Tab. 5. Basic structural characteristics (composition) of 'Hilly dry grasslands landscapes' group

Land cover class	Area (ha)	Area (%)
Transitional woodland-scrub	54652	32%
Pastures	44699	26%
Natural grassland	25906	15%
Broad-leaved forest	14664	9%
Complex cultivation patterns	6984	4%
Sclerophyllous vegetation	5965	4%
Sparsely vegetated areas	5450	3%
Land principally occupied by agriculture, with significant areas of natural vegetation	4888	3%
Non-irrigated arable land	1857	1%
Burnt areas	1684	1%
Coniferous forest	1512	1%
Other	1476	1%
Total	**169738**	

mild slopes, somewhat highly rugged with ravines and dales. Climate is warm Continental with Mediterranean influence. The vegetation specifics of the Hilly dry grasslands landscapes are determined by the geological background while their structure and character is highly influenced by the type and intensity of the grazing practices.

The composition of landscape types within this landscape group is largely uniform and determined by the dominant participation of the land cover classes *Pastures*, *Natural grasslands* and *Transitional woodland-scrub* (Tab. 5). However, this landscape has rural feature as well, which is determined by the presence of the classes *Land principally occupied by agriculture, with significant areas of natural vegetation* and *Complex cultivation patterns*.

The participation of the dominant land cover classes that represent the grasslands

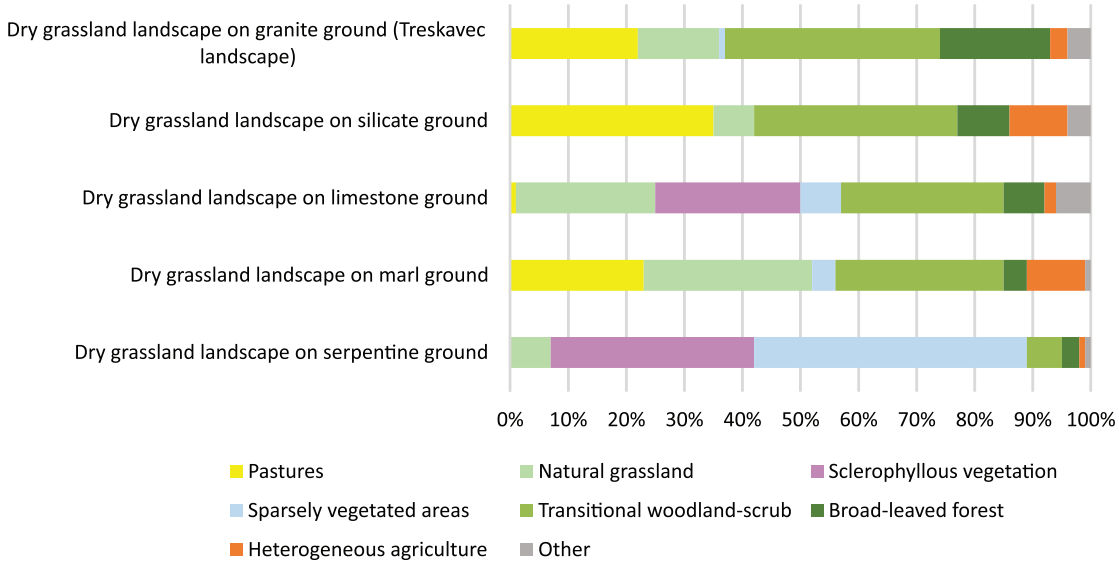

Fig. 6. Overview of land cover class participation in 'Dry grasslands landscapes' composition by landscape type.

Note: For the purpose of this graph *Heterogeneous agriculture* includes: *Land principally occupied by agriculture, with significant areas of natural vegetation, Complex cultivation patterns*, *Vineyards* and *Fruit trees and berry plantations.*

(*Pastures, Natural grasslands, Sclerophyllous vegetation, Sparsely vegetated areas*) shifts between landscape types and largely depends on the geomorphological and vegetation specifics (Fig. 6).

Matrix is composed of open land with pastures and natural grasslands with somewhat significant areas under pastures with shrubs (reflected by the class *Transitional woodland-scrub)*. Patches of natural habitats are scattered around the matrix and mainly represented by pubescent oak-hornbeam woodlands, scrublands (mainly of garland thorn) bare rocky grounds, eroded areas, steep rocks, etc. Corridors are disjunctive and mainly situated along rivers and streams.

Forest landscapes

Forest landscapes occupy 39% of the total area of North Macedonia and are represented by 7 landscape types (Tab. 1, Fig. 2, Fig. 3). Most dominant forest landscape type in North Macedonia is 'Mesophilous broadleaf forest landscape' (47%) followed by 'Thermophilous degraded forests landscape' (34%).

Forest landscapes are distributed on an average elevation that ranges from 380 m ('Pseudomaquis landscape'; see Fig. 2, code 6) to 1540 m ('Spruce-fir forest landscape'; see Fig. 2, code 30). This landscape has quite a varied relief mostly presented with mild to moderately steep and steep slopes, then gorges, ravines and valleys. Considering the high difference in elevation, the climate variances span from sub-Mediterranean to warm Continental and Continental with Mountainous.

Forest landscapes in North Macedonia have largely retained their natural features, especially those forest landscapes that are inaccessible. The anthropogenic influence is reflected primarily in the use of areas under forests for livestock breeding and agriculture (small fields and meadows, forest clearings), for firewood and construction material and partly for extraction of minerals and mining (mostly in the eastern part of the country). Today, most of these traditional extensive practices are abandoned or are in the process of abandonment. Landscape types within this landscape group typically have no human settlements, though individual houses, sheepfolds and other man-made structures are present. Many of these objects are also abandoned. Anthropogenic influence is prevalent and therefore most visible in the belt of thermophilous oak forests.

The character of these landscapes is determined by the dominant participation of land cover classes of *Broad-leaved forests*, while the significant contribution of 'Thermophilous degraded forests landscape' contributes to higher presence of *Transitional woodland-scrub* (Tab. 6). Individually, landscape types within this group largely differ in terms of composition and arrangement of elements (Fig. 7).

The matrix is represented by different forest communities representative for each forest landscape type: starting with Xerothermophilous forests (*Coccifero-Carpinetum orientalis*), then Thermophilous oak forests (dominated by *Querco-Carpinetum orientalis* and *Quercetum frainetto-cerris*) and Mesophilous forests (dominated by sessile oak (*Orno-Quercetum petraeae*) and moesian

Tab. 6. Basic structural characteristics (composition) of 'Forest landscapes' group

Land cover class	Area (ha)	Area (%)
Broad-leaved forest	543158	55%
Transitional woodland-scrub	235318	24%
Mixed forest	41828	4%
Natural grassland	35739	4%
Coniferous forest	35114	4%
Pastures	27451	3%
Land principally occupied by agriculture, with significant areas of natural vegetation	21623	2%
Sclerophyllous vegetation	16709	2%
Complex cultivation patterns	9670	1%
Water bodies	13197	1%
Total	**979807**	

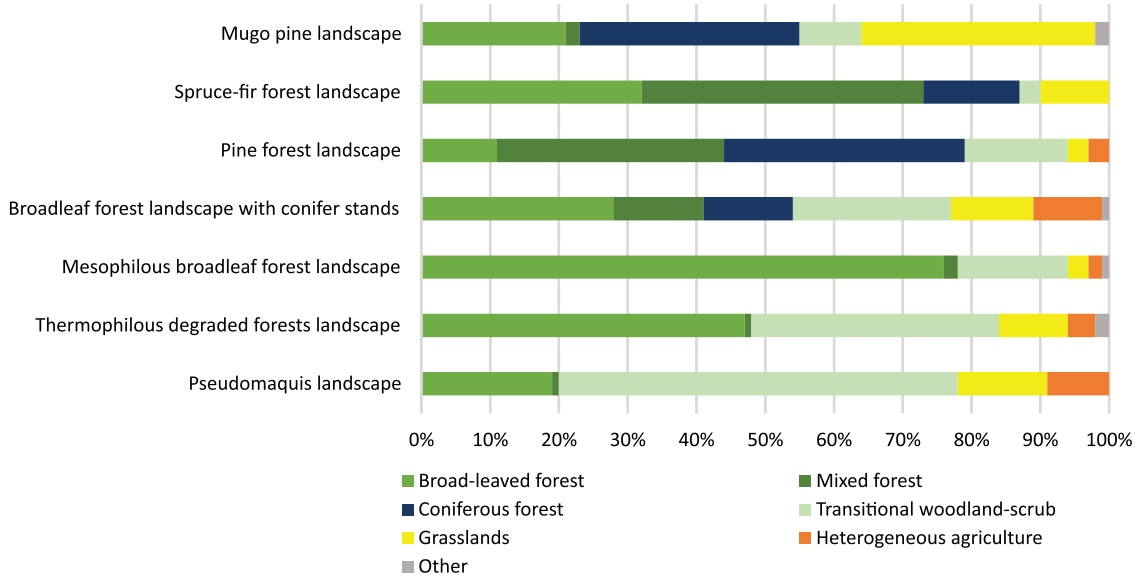

Fig. 7. Overview of land cover class participation in Forest landscapes composition by landscape type.

Note: For the purpose of this graph *Heterogeneous agriculture* includes: *Land principally occupied by agriculture, with significant areas of natural vegetation, Complex cultivation patterns*, *Vineyards* and *Fruit trees and berry plantations. Grasslands* includes: *Pastures, Natural grasslands and Sparsely vegetated areas.* In the case of 'Pseudomaquis landscape'*, Sclerophyllous vegetation* is included in the *Transitional woodland-scrub.*

beech forests (e.g. *Festuco heterophyllae-Fagetum* and *Calamintho grandiflorae-Fagetum*)) to mixed forests with dominant pine forests (*Pinus sylvestris, Pinus nigra* and *Pinus peuce* and *Pinus mugo*) and spruce-fir forests (*Abies borisii-regis, Picea excelsa*). Patches are represented by numerous meadows, small fields and pastures (grasslands).

Landscape types within this group are natural in character and considering their large coverage and their interconnectedness, forest landscapes serve as core habitat areas and have high importance as corridors facilitating movement throughout different forest landscapes and also serve to provide links to (or in-between) Mountain grasslands landscapes and Rural landscapes. Hence, landscape types within this group have high importance in terms of biodiversity conservation, especially with reference to large carnivores.

Mountain grasslands landscapes

Mountain grasslands landscapes occupy only 5% of the total area of North Macedonia and are represented by only 2 landscape types (Tab. 1, Fig. 2, Fig. 3).

Mountain grasslands landscapes are distributed on an average elevation of about 1800 m. The relief is mountainous, represented mainly by mild to moderately steep slopes. Considering the high altitude, the climate is Mountainous.

Mountain grasslands landscapes are characteristic only for the high (mainly subalpine and partly alpine) parts of the high mountains in North Macedonia. In this part of the Balkan Peninsula, the mountain grasslands would have potentially been distributed over 2200 m a.s.l, but as a result of a long lasting tradition of grazing herds of numerous sheep and cattle, the line of the forest belt was artificially lowered by about 300-500 m (Kolchakovski 1994; Melovski et al. 2010a).

Considering the country's geomorphology and relief, 'Mountain grasslands landscapes' are dominantly distributed in western parts of North Macedonia. The specifics of the landscape types within this group are given by the substrate (carbonate and silicate) that in conjunction with other ecological factors (temperature, humidity, exposition) determines both the presence and distribution of specific vegetation types and determines the functional characteristics of the landscapes i.e. ecosystem dynamics in terms of flow of energy and matter balance. The vegetation

Tab. 7. Basic structural characteristics (composition) of 'Mountain grasslands landscapes' group

Land cover class	Area (ha)	Area (%)
Natural grassland	103558	78%
Moors and heathland	11294	9%
Transitional woodland-scrub	5956	4%
Broad-leaved forest	3878	3%
Burnt areas	3296	2%
Pastures	2209	2%
Sparsely vegetated areas	1185	1%
Other	1488	1%
Total	**132866**	

in this highest elevation belt (zone) is not presented by certain dominant plant community (as in the case of forest belts), but by a mosaic of different communities (and habitats, accordingly). Merging of all these communities into one belt is based only on their external similarity (low grass perennial plant life forms, grasses and sedges).

The matrix of the landscape is represented by a dominant presence of the land cover class of *Natural grasslands* followed by *Moors and heathland* (Tab. 7). Patches are represented by a variety of woodlands, wetlands (pools, peat bogs, glacial lakes, springs, streams) or rocks and screes. Heaths of blueberry and low juniper are very common and form large patches or even dominate in some areas. Man-made landscape elements are site specific and usually include sheepfolds and tourist infrastructure. Anthropogenic activities include sheep breeding during summer, less frequently cows and cattle grazing, as well as collection of wild fruits (berries) during summer. Abandonment of livestock breeding practices (i.e. reducing its intensity) has resulted in increased area of heaths.

Mountain grasslands landscapes have great importance for biodiversity conservation because these host significant portion of rare and endemic species of organisms.

Mountain rocky landscapes

'Mountain rocky landscapes' occupy less than 1% of the total area of North Macedonia and are represented by only 2 landscape types (Tab. 1, Fig. 2, Fig. 3).

Mountain rocky landscapes are distributed on an average elevation of about 2130 m. Relief is mountainous, mainly represented by steep to moderately steep slopes and/or rocks and very steep slopes. The climate is Mountainous. The specificities of the landscape types within this group (as in the case of 'Mountain grasslands landscapes') are given by the substrate (carbonate and silicate). Areas under mountain grasslands on rocky ground (sufficiently representative to be delineated as a landscape) are found only on the highest peaks on the high mountains in the western (Shar Planina and Korab) and

Tab. 8. Basic structural characteristics (composition) of 'Mountain rocky landscapes' group

Land cover class	Area (ha)	Area (%)
Natural grassland	4888	64%
Sparsely vegetated areas	1212	16%
Moors and heathland	650	9%
Transitional woodland-scrub	322	4%
Bare rocks	233	3%
Mixed forest	169	2%
Coniferous forest	85	1%
Broad-leaved forest	73	1%
Total	**7632**	

central parts (Jakupica) of North Macedonia.

Landscape matrix is represented by mosaic of natural grasslands on rocky grounds, sparsely vegetated areas and rocks and rocky grounds (Tab. 8). Mountain rocky landscapes are characterised by extremely harsh conditions for survival of the inhabiting species. For these reasons, Mountain rocky landscapes abound in specialist species, most of which are endangered, rare and endemic. Flocks of chamois, vultures and other rare birds find shelter here. Given the harsh conditions and low anthropogenic pressure Mountain rocky landscapes have remained highly natural and preserved. Poaching and improper herbs collection are the only threats detected.

Mountain rocky landscapes also have great importance for biodiversity conservation.

Lake landscapes

Lake landscapes occupy only 3% of the total area of North Macedonia and are represented by 3 landscape types (Tab. 1, Fig. 2, Fig. 3) accommodated in the lake basins of the three tectonic lakes: Dojran, Ohrid and Prespa Lake. While the relief within the lake basins is dominated by plains, the lake basins are surrounded by mountainous relief. Due to their location and the specifics of the surrounding relief all lake basins have very different elevation range (average elevation ranges from 160 m ('Dojran landscape'; see Fig. 2, code 7) to 850 m ('Prespa Landscape'; see Fig. 2, code 9) and are influenced by different climate variances. Therefore, all lake basins are characterised by different natural vegetation specifics as well as different anthropogenic specifics (different past and present socio-cultural trends and socio-economic policies, different land use and agricultural practices).

Main characteristic of the Lake landscapes is the dominant presence of a large water mass (Tab. 9) accompanied by the presence of agricultural land with differing agricultural types specific for each lake basin. In 'Ohrid landscape' the agricultural land (36%) is largely presented by the class of *Complex cultivation patterns* (20%) accompanied by the class *Non-irrigated arable land* (8%). Other specific of this landscape is the urbanised area (including the tourist facilities) surrounding lake Ohrid. In 'Dojran landscape' the agricultural land (41%) is dominantly presented by the land cover class of *Complex cultivation patterns* (17%) and *Vineyards* (16%). In the case of 'Prespa landscape', that is the largest apple producing region in the country, most of agricultural land (31%) is presented by the class *Fruit trees and berry plantations* (21%). Alike Agricultural landscapes, patches of natural vegetation within the agricultural land are sparse and represented by small plots of anthropogenic tree stands, with remnants of pubescent oak and hornbeam forests, xerothermic shrubs and grasslands. 'Dojran landscape' and 'Prespa landscape' are more rural in character and are characterised by high presence of wetlands (especially 'Prespa landscape').

Lake landscapes have great importance

Tab. 9. Basic structural characteristics (composition) of 'Lake landscapes' group

Land cover class	**Area (ha)**	**Area (%)**
Water bodies	45013	59%
Complex cultivation patterns	10990	14%
Fruit trees and berry plantations	7043	9%
Non-irrigated arable land	5081	7%
Land principally occupied by agriculture, with significant areas of natural vegetation	2416	3%
Discontinuous urban fabric	1812	2%
Inland marshes	1595	2%
Vineyards	887	1%
Transitional woodland-scrub	717	1%
Broad-leaved forest	434	1%
Other	1327	2%
Total	**76927**	

for biodiversity conservation. Their high conservational importance relates to the water surfaces and the surrounding wetlands that host significant portion of rare and endemic species with high national and global importance for conservation. Due to their highly valued natural and cultural specifics, both Ohrid and Prespa Lake have several national and international designations: "Ohrid" UNESCO World heritage site, Monument of nature "Ohrid Lake", Monument of nature "Prespa Lake", Nature Park "Ezerani", "Ohrid-Prespa" Transboundary Biosphere Reserve and both lakes are designated as Important bird areas and Important plant areas (Melovski et al. 2010b; Velevski et al. 2010; Melovski et al. 2012). Lake Dojran is also designated as an Important bird area and both Lake Prespa and Lake Dojran are designated as Ramsar sites.

Valorisation

Landscape valorisation is based on 6 criteria (see Methods), all having equal contribution to the final valorisation value. The valorisation results range from 0 to 16. Landscape value with reference to conservation, visual quality and uniqueness generally increases with landscape naturalness. This is notable even in the case of valuation of socio-cultural values as landscape types whose character is a result of traditional and culturally specific extensive land use practices are also mostly extensively managed and more "nature friendly". Landscape valorisation results are presented in Tab. 10.

Threats

Threats to landscapes are complex and brought up by local, national and regional socio-economic, political and development policies. Complexity is attributed by the fact that each landscape is made of number of ecosystems affected by series of ecosystem specific processes. Also, certain threats that lead to change in landscape structure can be beneficial for biodiversity but result in loss of landscape specifics that attribute its appearance. For example, overgrowth of rural landscapes results in loss of visual specifics, but creates larger patches of scrubland, followed by succeeding forest vegetation ultimately reducing the fragmentation of favorable habitats for wild species. Thus, certain threat can have positive effects by increasing connectivity of natural habitats and benefit biodiversity while having adverse effect on landscape character and its visual quality. Yet, this is not entirely true either – uniform landscape structure assumes loss of habitats too (meadows, hedgerows, pastures) that leads to loss of secondary anthropogenic habitats which are also significant for the preservation of biodiversity.

Finally, as one same process affects different landscape types in a different manner, most of the identified threats are listed with reference to landscape types.

- *Abandonment of traditional livestock breeding practices* (i.e. reducing its intensity) increases the area of heaths and scrubs and leads to successional forest overgrowth. This process affects the structural and functional properties of Hilly dry grasslands landscapes and Mountain grassland landscapes. While in the case of Hilly dry grasslands landscapes this process increases the connectivity between forest patches, in both cases it leads to loss of biodiversity linked to pastures and grasslands.
- *Abandonment of traditional agricultural practices* leads to scrub encroachment, loss of hedge structural specifics and loss of areas under fields and meadows ultimately leading to loss of species diversity linked to these secondary anthropogenic habitats. This process affects Rural landscapes and its effects are especially notable in the appearance of Mountain rural landscapes. Although, the effects are also notable in Rolling rural landscapes (especially Rolling rural landscapes with hedges) and Hilly rural landscapes (especially 'Mariovo landscape' where rural-urban migration concluded in the past decade) .
- *Intensification of agricultural practices* leads to loss of small-scale agriculture and loss of hedges thus affecting corridor arrangement and limiting corridor functionality in the Agricultural landscapes. Intensification of agricultural practices also leads to more uniform structure and thus affects the visual quality of Agricultural landscapes.
- *Urbanisation and industrialisation* (surface pits and quarries included) negatively affect both structural and functional characteristics of landscapes and also have an adverse effect in terms of landscape visual quality. The negative effects of urbanisation are visible in Lake landscapes,

Tab. 10. Valorisation of landscape types. For detailed landscape types nomenclature see Tab. 1.

Landscape type code (Fig. 2)	Landscape area (%)	Landscape type	Character and condition	Natural value	Cultural value	Sensitivity	Connectivity	Uniqueness	Total
30	0.3	Spruce-fir forest landscape	3	3	1	3	3	3	16
7	0.2	Dojran landscape	2	3	3	2	2	3	15
38	2.2	Landscape of mountain grasslands on limestone ground	3	3	1	2	3	3	15
9	1.2	Prespa landscape	2	3	3	2	2	3	15
28	2.7	Pine forest landscape	3	3	1	2	3	2	14
33	1.7	Dry grassland landscape on marl ground	3	3	1	2	3	2	14
29	0.1	Mugo pine landscape	3	2	1	3	2	3	14
39	0.2	Landscape of limestone rocky ground	3	3	1	1	3	3	14
37	0.1	Landscape of silicate rocky ground	3	3	1	1	3	3	14
18	0.4	Rolling rural landscape with hedges	2	2	3	2	2	3	14
22	3.2	Osogovo mountain rural landscape	2	2	3	2	3	2	14
24	0.6	Reka mountain rural landscape	2	2	3	2	2	3	14
8	1.7	Ohrid landscape	2	3	3	2	1	3	14
35	0.2	Dry grassland landscape on serpentine ground	2	3	1	2	2	3	13
11	0.6	Kochani landscape	2	1	3	2	2	3	13
14	2.3	Mariovo landscape	1	2	3	2	2	3	13
34	0.7	Treskavec landscape	2	3	3	1	2	2	13
20	0.6	Maleshevo mountain rural landscape	2	2	3	2	1	3	13
21	1.4	Mountain rural landscape	2	2	3	2	2	2	13
23	0.3	Mavrovo mountain rural landscape	2	2	3	2	2	2	13
6	2.3	Pseudomaquis landscape	2	3	1	2	3	2	13

Landscape type code (Fig. 2)	Landscape area (%)	Landscape type	Character and condition	Natural value	Cultural value	Sensitivity	Connectivity	Uniqueness	Total
32	0.7	Dry grassland landscape on limestone ground	2	3	1	2	2	2	12
19	8.3	Hilly rural landscape	2	2	3	2	2	1	12
3	4.9	Pelagonia landscape	2	3	2	2	1	2	12
26	18.2	Mesophilous broadleaf forest landscape	2	3	2	1	3	1	12
36	3	Landscape of mountain grasslands on silicate ground	2	3	2	1	3	1	12
12	0.7	Maleshevo-Pijanec landscape	3	2	2	2	1	2	12
10	0.8	Ovche Pole flatland landscape	2	2	2	2	1	2	11
13	2.1	Tikvesh landscape	2	2	3	1	1	2	11
1	2	Flatland sub-Mediterranean agricultural landscape	2	2	3	1	1	2	11
4	1.1	Polog landscape	3	1	3	2	1	1	11
5	1.4	Flatland-rolling sub-continental agricultural-rural landscape	2	2	2	1	2	1	10
16	1.2	Rolling agricultural-rural landscape	2	1	2	2	1	2	10
17	8	Rolling rural landscape	2	1	2	2	2	1	10
31	3.3	Dry grassland landscape on silicate ground	1	2	2	2	2	1	10
15	3.9	Rolling agricultural landscape	2	1	2	2	1	1	9
2	1.4	Flatland sub-Mediterranean-continental agricultural landscape	2	1	2	2	1	1	9
25	13.1	Thermophilous degraded forests landscape	2	2	1	1	2	0	8
27	1.8	Broadleaf forest landscape with conifer stands	2	2	1	1	1	0	7
41	0.7	Urban landscape	1	0	2	1	0	0	4
40	0.1	Industrial-mining landscape	1	0	0	0	0	0	1

but also in many of the Agricultural landscapes e.g. 'Polog landscape'. In 'Polog landscape' there is a continuous increase in urban area due to the specific conglomeration that occurs as the villages gain urban features and tend to merge, thus contributing to the formation of a longitudinally arranged urban setting. The negative effects of surface pits and quarries are usually linked to loss of landscapes visual appeal, but considering the scale of alteration of natural habitats negative effects of surface pits and quarries are accompanied by fragmentation, habitat and biodiversity loss.

- *Fragmentation*, resulting from infrastructure development with reference to linear infrastructure (especially highways), energy production and tourist infrastructure. During both the constructional and operational stage, infrastructural projects do not bend to accommodate the mitigation recommendations and are often accompanied by inadequate forest management (erosion, clear-cut), habitat degradation and biodiversity loss. Fragmentation mostly affects the structural and functional properties of Forest landscapes, though due to recent initiatives for hydropower development and tourist infrastructure development Mountain grasslands landscapes are also affected. Forest fires also contribute to fragmentation and habitat degradation in Forest landscapes (especially 'Thermophilous forests landscapes' and 'Pseudomaquis landscape').
- *Afforestation,* especially relevant for Hilly dry grasslands landscapes. Recent afforestation done with allochthonous, mostly conifer species altered the structural and functional properties of Hilly dry grasslands landscapes in many areas of northeast and central parts of North Macedonia, ultimately affecting their appearance. Afforestation also increases the risk of fires.

Discussion

The word *landscape* (предел in Macedonian) today finds its use in a wide array of subjects, from poetry to politics. Its wide use is followed by broad definitions that apply to the meaning of landscape (see e.g. Oxford Dictionary and Merriam-Webster Dictionary). In environmental and conservation sciences, 'landscape' is commonly associated with the physical aspects of the environment and usually referred to as framework for research or as a continuous extent of land cover. Even in landscape ecology, there is a wide context to its definition (Turner et al. 2001; Burel and Baudry 2003) with a common string: landscape is a spatially heterogeneous area of interacting ecosystems with recognisable spatial pattern amended by the anthropogenic processes and practices. This definition outlines the importance of spatial configuration of physical elements of the environment for ecological processes (both composition and arrangement) over large spatial extents while considering the specifics of human activities as one of the factors contributing to spatial heterogeneity (Turner et al. 2001). With respect to ecology, landscape exists independently of perception (Burel and Baudry 2003). The European Landscape Convention (Council of Europe 2000) recognizes both and defines landscape as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors".

In response to the Article 6 of European Landscape Convention (Council of Europe 2000) a variety of approaches to landscape identification has been implemented across Europe (Kindler 2005). Existing national and regional landscape typologies and classifications, differ in terms of methodology, input data, scale of application and nomenclature (Groom 2005; Kindler 2005; Mücher et al. 2010). Although landscape classification parameters vary in terms of their presence and contribution in defining the character of any particular type of landscape, similarities do exist. Most approaches to landscape classifications define landscape as a particular configuration of environmental (climate, topography, geology, soils, vegetation cover) and anthropogenic features (land use, settlement pattern, cultural/social factors, historicity and landscape perception). In many European countries, landscape classification is mainly biophysical and thus reflects ecologically homogenous units in hierarchical aggregation levels that correspond to one or several criteria (Lioubimtseva and Defourny 1999; Chmielewski et al. 2015; reviews available in Kindler 2005). The anthropogenic imprint on the landscape is defined by land use and settlement patterns. Identified landscape types mostly reflect the geo-physical properties of landscapes as nomenclatures mostly refers to climate, relief and vegetation cover without considering the cultural and historical specifics.

In the United Kingdom, former studies

dealing with landscape classification (Blankson and Green 1991; Kindler 2005) also focus on landscapes' physical characteristics and classify landscapes by clustering landscape attributes (relief, elevation, topography, geology, vegetation and land use) into homogeneous landscape units. Today, landscape classification is considered as building block of landscape characterisation. Used as a prerequisite to landscape assessment Swanwick (2002) promotes landscape characterisation as more 'holistic' approach that draws on multiple aspects of landscapes: physical attributes of the environment (geology, landform, soils, vegetation); both the historical and current influences of human land use and settlement; cultural/social factors and perception (see also LANDMAP for Wales (Natural Resources Wales 2019)). Considering the different aspects contributing to landscape character (both subjective/biophysical and objective/ perceptual) it is widely interpreted (Caspersen 2009) and there are various approaches to its assessment, even in UK (Tudor 2014; Fairclough and Herring 2016).

However, depending on the specific objectives of classification, the input data and the scale of application landscape classifications results essentially differ and are difficult to associate and compare (Kindler 2005). In response, several studies have made attempt to provide unifying methodological framework for landscape classification in Europe. The Pan-European landscape classification provided by Meeus (1995) was amongst the first attempts to provide information on the European landscapes, though resulting Pan-European landscape types reflect the character and distribution of biomes rather than landscapes. This study nonetheless sets the methodological and conceptual basis for landscape classification on a continental scale. Since, most comprehensive continental landscape classification is provided by Mücher et al. (2010). European landscapes are classified in four hierarchical levels; using digital data on climate, elevation, parent material and land cover. Considering the scale and scope, the European landscape map (LANMAP) provided by Mücher et al. (2010) is limited to biophysical approach and does not reflect the cultural-historic specifics of land use. Nonetheless, Mücher et al. (2010) provide methodology baseline with nomenclature guidance and is the first coarse reference to landscape diversity on the Balkan peninsula, a part of Europe where data on landscape diversity are scantest.

Yet, robust land classifications that provide integral descriptive analysis of physical and ecological characteristics of territories of former Yugoslav republics date back to the 1960s. The specifics and distribution of biogeographical provinces of Yugoslavia, classified in four hierarchical levels, were first published by Matvejev (1961). The author provides overview of biomes determined by climate (zonobiomes) and altitude (orobiomes), later updated with cartographic representation (Matvejev and Puncer 1989) and description of biomes with reference to palaeogeography, palaeoecology, ecology and biogeographical specifics (Lopatin and Matvejev 1995). Other relevant classification is that of Filipovski et al. (1996) that provides description and cartographic representation of specific vegetation, climate-vegetation and climate-vegetation-soil zones determined by elevation. The outputs of these classifications generally correspond to natural landscape types identified within the landscape groups: Forest landscapes, Mountain grasslands landscapes and Mountain rocky landscapes (see results).

Methodologically, this study largely relies on distribution of vegetation zones (Matvejev and Puncer 1989; Lopatin and Matvejev 1995; Filipovski et al. 1996) as these reflect the main elevation belts relative to which defining landscape criteria are set in the matrix (Tab. 1). Other major determinants of delineating landscape types were relief, climate (with consideration of relief-climate interrelation), geology and soils as determinants of vegetation types, land use and settlement patterns. Bearing in mind that land becomes landscape only when its cultural values are recognised (that are especially relevant for the landscapes of the Balkan Peninsula) this study gives reference to land use and landscape cultural specifics with landscape visuality in mind. Criterion of "general public perception" was not implemented, but specific features of certain regions (in wider national context) were used to name certain landscapes (subjectively, based on the perception of the authors of this study).

Basically, the national typology presented in this study is a result of the combination of biophysical attributes (elevation, relief, climate, geology and soils and land use/cover), includes study and synthesis of available geographic and ecological literature dealing with land classification, with consideration of spatial attributes and visual interpretation complemented by field work and scientific expertise. Unlike, many landscape classifications rely solely on combined interpretation of geo-

physical properties of landscapes (climate, topography, parent material, land use/land cover) by using digital spatial information and computer supported data processing e.g. Lioubimtseva and Defourny (1999). When aiming for landscape classification on a very coarse scale (e.g. continental scale) biophysical approach to landscape classification suffice (Mücher et al. 2010). Nonetheless, the biophysical approach has substantial deficiencies, especially for it neglects the visual aspect and specific features of certain spatial entirety. This concerns mainly the cultural aspect of the landscape (division in land plots, pattern of occupation, manners of cultivation and historical momentum - abandonment of cultivation). Due to lack of consistent cultural-historical data these aspects cannot be included adequately in digital data processing (Mücher et al. 2010) which is not significant disadvantage on a coarse scale (on vast areas). But, when identification of landscape types is carried on a smaller territory (like North Macedonia), the rough GIS product of landscape types should be complemented by field surveys, taking into account both environmental specifics and basic cultural aspects of the area. This approach has certain deficiencies: it is time consuming and involves a dose of subjectivity (results depend on the experience, expertise and field-specific knowledge of the expert). Conceptually, the national landscape classification of North Macedonia shares commonalities with landscape classifications of Germany, Austria and Hungary, particularly Spain (reviewed in Kindler 2005) and draws parallels with the concept of landscape characterisation presented in Swanwick (2002). Considering the differences in scale, concepts and criteria, the fine scale results of this study are not directly comparable to the European landscape classification (Mücher et al. 2010) does not provide reference to plains and flatlands in North Macedonia. Still, on a higher level of landscape organisation i.e. landscape groups, parallels can be drawn with reference to Urban and industrial-mining landscapes, Agricultural landscapes, Forest landscapes, Lake landscapes and even Rural landscapes.

Landscape classification, as presented here, could be further improved and could further benefit from fine scale studies that will allow fine adjustments of boundaries of identified landscape types and distinction of region specific landscape sub-types. Considering the scope of this study, the structural properties of identified landscapes are general (subject to data availability) and provide details solely with reference to landscape composition. Region specific studies could also contribute towards more detailed structural analysis with regards to configuration and functionality in terms of corridor presence and importance, as well as biodiversity and ecosystem processes. By far, such detailed landscape assessment with reference to patch composition and arrangement is available for the agricultural and rural landscapes in the northeast of North Macedonia (Jovanovska et al. 2017). The study shows that capacity to sustain biodiversity levels up in rural landscapes and is most perceptible in 'Hilly rural landscape', 'Mountain rural landscape' and 'Osogovo mountain rural landscape', providing reference to other landscape types alike. Studies dealing with landscape connectivity that determine the importance of landscapes as a wildlife habitats and corridors are scarce (Hristovski et al. 2016). Studies that determine the importance of landscapes as a wildlife habitats and corridors for large mammals are practically missing (with exclusion of few scientific presentations and project reports e.g. Melovski et al. 2015; Avukatov et al. 2016).

With reference to landscape valorisation provided in this study, the purpose is to provide a general insight of landscapes' value with reference to landscape character, resilience and sensitivity, uniqueness, landscape capacity in terms of biodiversity conservation and landscape natural and cultural values. Restricted by the scope of this study and data availability, landscape valorisation approach is indicative and based on expert judgement. Thus, further detailed and integral assessment on landscapes value with consideration of both ecological (Bastian 2000; Zhang et al. 2016) and perceptual qualities of the individual landscape units is needed. In this regard, this study also encourages further detailed fine scale assessment on landscape visual quality (Ramos and Pastor 2012; Tratalos et al. 2016; Swetnam et al. 2017) with consideration of 'general public perception' (Rogge et al. 2007; Barroso et al. 2012; Swetnam and Tweed 2018) including assessment on socio-cultural importance of landscapes.

These detailed assessments will also provide specifics that will complement the general list of threats provided within this study. Identifying landscape threats is daring and complex task corresponding with the complexity of factors that cause degradation of landscape values. Identified general threats should be detailed featuring threats specific

for each landscape type and be accompanied by corresponding management actions and recommendations (Bastian 2000) drafted with consideration of both social (especially economic) and ecological aspects in a holistic manner.

Comprehensive landscape classification is recognised to be a prerequisite for further integral systematic environmental and socio-economic assessments (Blankson and Green 1991) that allows to monitor environmental change (Hunziker et al. 2008; De Pablo et al. 2012); provides a broad scale perception of the conservation challenges and requirements; and provides an effective framework for land management and planning with consideration to nature conservation, cultural heritage and human development.

Landscape classification provided in this study is the first publication of this kind in the region of Southeast Europe. Considering the commonalities of both natural and cultural landscapes in the Balkans, we hope that this study could serve as a methodological and conceptual guideline for succeeding national landscape classifications in the region. Featuring information on landscape diversity will provide a broad scale perception of the conservation requirements in the region and will align regional conservation policies and management by giving the future conservation endeavors a landscape approach.

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