MAPPING LANDSCAPE TYPES IN SOUTH PIRIN AND SLAVYANKA MOUNTAIN IN BULGARIA USING REMOTE SENSING

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Abstract
This study aims to produce a detailed landscape map and classification that provide an important tool for integrated environmental analysis and monitoring. The chosen study area South Pirin and Slavyanka mountain represents a conditionally natural area in Bulgaria. Being such kind of area the creation of large-scale landscape map involves few steps: to define and to classify different landscape types, to evaluate their conservation significance and to analyze their integrity. The data used includes: geological map, soil map, topographic maps, climate data, land cover and land use data. Satellite and orthophoto images were also used for more accurate mapping of landscape types. Mapping landscape types, based upon consistent scientific approach is essential for integrated environmental assessment, protection, monitoring and management. Landscapes are ecological meaningful units where both the natural (abiotic and biotic) and the anthropogenic (land use) components and processes interact.

Keywords*: South Pirin, Slavyanka mountain, Landscape map, Remote sensig*

INTRODUCTION

The actuality of research of the contemporary condition of the landscapes is connected with sustainable development problems and anthropogenic influence on the environment. This is even more important for mountain areas in Bulgaria, because in these regions there are various protected areas. In conjuction with the development of modern geoinformation technologies very important is obtaining digital quantitative and qualitative data for the condition and changes in the landscapes. Therefore, more and more widely used are geographic information systems (GIS) and remote sensing.

In mountainous areas on the border between Bulgaria and Greece landscapes are poorly studied, because there is no fully and thorough landscape studies. Single studies have been made by several authors for separate parts of the region. In his book "Pirin" Popov (1966) gives information on geology, geomorphology, water, soils, vegetation and wildlife in Pirin mountain. In the past few years there are several authors that have worked for this area. Some geographical data for South Pirin and Slavyanka are presented by Nikolov et al. (2013), including detailed geography characteristics, maps, charts and tourist routs. Landscape and geographical researches in the northern slope of Slavyanka mountain are made by Kitev (2013), Dimitrov (2014), Kitev et al. (2014), Kitev (2014) and Penin, Kitev (2016). A study on the land use/cover is performed by Kitev, Vatseva (2014), and studies for hemeroby of Slavyanka are made by Dimitrov, Sarafov (2015).

This study aims to classification, identification and mapping contemporary landscapes in South Pirin and Slavyanka mountain regions in Bulgaria. For achieving these aims the following task are set: to establish the current condition of the landscapes by identifying and characterizing the landscape forming factors and classifying them, as well as creation of landscape map.

DATA AND METHODS

Study area covers the mountainous territory of South Pirin and Slavyanka (41° 22` – 41° 34` N and 23° 24` – 23° 47` E) with an area of 404,18 km^2 (40 418 ha). This area is located in southwestern Bulgaria. The area is diverse in nature. The lowest point is 114 m above sea level at the exit of Pirinska Bistritsa river of the territory of Bulgaria, and the highest point is 2212 m – Gotsev vrah, the highest peak of Slavyanka mountain. The study area is included in the Rilo-Rhodope

block step and in particular to Pirin elevated block morphostructure. South Pirin and Slavyanka falls within the Continental-Mediterranean climate area, characterized with a warm summer and mild winter in most of the region the mountain climate occurs. The area falls within the Aegean drainage area. The territory is influenced by the Mediterranean climate influence on the flow field and moderate continental climatic influence on runoff. The study area falls into two floristic regions – Slavyanka and Pirin. The area is covered by immoral type vegetation (deciduous broadleaf): mesophytic and xeromesophytic, and xerothermal. Also a formation of Bosnian pine (Pineta Heldreichii) is observed in the study area, and a biosphere reserve "Alibotush" in Slavyanka mountain protects these forests of Bosnian pine (*Pinus heldreichii*) – one of the largest fields in the world.

The subject of this study is the landscapes in South Pirin and Slavyanka. The object of the study is the classification of landscape units at the level of subtypes.

For creating a map of the contemporary landscapes of the study area in GIS environment were used georeferenced digital maps including geological map – scale 1:100 000, soil maps – scale 1:400 000 and 1:200 000, landscape map of Bulgaria – scale 1:500 000, data for land cover and land use in Bulgaria for 2012 in scale 1:100 000 (corrected by the author based on satellite images and orthophoto images), topographic maps in scale 1:50 000, georeferenced colour orthophoto images taken in 2006 (http://gis.mrrb.government.bg) and Landsat satellite images (www.landsat.org).

The classification of landscapes in the research area was made based on the classification system of Velchev, Todorov and Berouchashvili (1989), which is perceived gradation of taxonomic units: class, type, subtype, genus and kind of landscapes. On this study is added the taxonomic unit subclass. This taxon was introduced in class plains and foothills to clarify that this part of the study area falls in a mountain-hilly areas. The subgenus is separated on the basis of geological foundation. For the lowest taxonomic rank is accepted subkind based on the developed nomenclature through the project CORINE Land Cover at 3rd level (CEC, 1995, Bossard et al., 2000; EEA, 2007). Using a consistent scientific approach, comparison and juxtaposition of such sources is composed landscape map. The determination of landscapes from different taxonomic rank and establishing their borders is made by way of comprehensive and multi-factor analysis of expression of factors for landscape differentiation. In the beginning were studied existing cartographic and literature sources and then a field research is done. There also are used satellite images form Landsat and orthophoto images, on which base a correction of the existing database of CLC 2012 was made for the study area – including major methodological approaches for mapping land cover and land use in GIS environment applied in researches Kopecka et al., (2014); Vatseva, (2015a); Vatseva, R. (2015b); Vatseva et al., (2016).

Creating a digital landscape map using GIS (ArcGIS 10.3) facilitates the analysis of the spatial distribution and provides calculation of number of indicators, characterizing the different landscape units.

RESULTS AND DISCUSSION

The digital map of contemporary landscapes in South Pirin and Slavyanka is in geographical coordinates, reference ellipsoid WGS1984, cartographic projection UTM (Universal Transverse Mercator) Zone 35 N. The map was developed in scale 1:100 000 and represents the location of the landscapes from the lowest taxonomic rank in the study area (fig. 1). On the territory of South Pirin and Slavyanka are found 179 subkinds landscapes represented by different types of agricultural lands and forests and semi-natural areas. The areas of the subkind level can be considered polygons with very precise accuracy due to additional corrections of CLC 2012 based on satellite images and georeferenced color orthophoto images.

The minimum size of each subkind landscape is 20 ha, some subkinds have a smaller area than the accepted for landscape map – due to need to be represented in this study. Some of them are border polygon subkinds for the study area (№ 2 and 4) while others are included in the map by the decision of the author, for more correct landscape diversity (№ 13, 14, 15, 16, 17, 19, 31, 110, 111 and 175).

The main task in each landscape study is the mapping of the landscapes. The creation of landscape map is an objective basis for analysis and assessment of the different landscape units. The selected classification must be selected properly with the aims and task of the study.

Any landscape study regardless of its task and scope of the study area is accompanied with landscape map. The landscape map is the end product and result of the pattern of landscape forming factors (Velchev et al., 1992).In the study of objects, phenomena and processes in every scientific field the consistent scientific approach provides first of all that they should be classified based on a logical sequence. The arrangement of landscapes in a certain system of taxonomic unit represents their classification (Petrov, 1990).

In this study, to show the location of the researched area in the landscape regionalization of Bulgaria was used the classification system developed by Berouchashvili for the territory of the Caucasus and Transcaucasia. It is partly modified by A. Velchev, N. Todorov, A, Assenov and N. L. Berouchashvili concerning specific conditions of the Balkan Peninsula. In the formation of large taxonomic units it is applied traditional approach to identification to classifications – "top-down". For this approach is characteristic that first the major taxonomic units are disclosed, and then they are divided into smaller units.

With the clarity of differentiation of the landscapes in the territory object of this study to the hierarchy of the adopted landscape classification system – class, type, subtype, genus and kind are added and subclass, subgenus and subkind.

The largest taxonomic unit is class landscapes. The criteria for its determination were developed by Gvozdetskii (1972). For leading factor is taken the relief and its geological content. On the territory of Bulgaria are separated two classes – mountain and plains and foothills. Study area falls in both classes.

The next taxonomic unit is subclass landscapes. This taxon was introduced in class plains and foothills, aims to clarify that this part of the study area falls in mountain-hilly areas.

Another taxonomic unit is type landscapes. According to several authors in this taxation unite territories with hydro-climatic conditions (the ration between heat and humidity) with similarities to the structure and same migration regime. According to these criteria in the researched area are separated six types: hydromorphic and subhydromorphic; mountain, warm-temporate submediterraniean; mountain, warm-temporate semihumid; mountain, warm-temporate humid; mountain, cold-temporate, humid and high-mountain meadow.

The next taxonomic unit that sometimes is separated within type is subtype landscapes. Its separation comes from secondary belt, zonal or bioclimatic signs (general nature of the vegetation). In the area are separated seven subtypes: humid mediterranean with plane tree forests; low-mountain submediterranean forest and shiblyak; transitional to submediterranean, hollow, forest and shiblyak; medium-height mountain forest; medium-height mountain, coniferous; high-mountain, mainly pine and high-mountain, subalpine dwarf pine and meadow.

Another classification unit is genus landscapes. It is taken into account the morphological features of the relief of lower rank as the predominant type of relief (contemporary processes forming relief, shape and elements). In this taxonomic unit are separated three genus landscapes: flood-plain and fluvial terrace above flood-plain; denudation surfaces and slope.

In landscape differentiation of the study area was added the taxonomic unit subgenus landscapes. It is separated on the basis of geological basis with its specific petrographic characteristics. There are four subgenus landscapes: on marbles; on metamorphic and igneous rocks; on sedimentary rocks and on alluvial-deluvium deposits.

The next taxonomic unit is kind landscapes. For the kind landscape are typical geological and geomorphological sign of lower rank (one kind of relief and a single petrochemical base), one soil type (subtype), single vegetation and microclimate features. In this study leading factor in the separation of kinds of landscapes is used only the soil, combined with the landscape units of superior rank. At this sign were separated 6 kinds of landscapes: Dystric/Eutric Fluvisols; eroded Chromic Luvisols; Chromic Luvisols; Cambisols; Rendzic Leptosols and Umbrosols.

The lowest taxonomic rank is subkind landscapes. In it there are 12 classes of land cover and land use nomenclature from the project CORINE Land Cover. They are represented by second and third class from the 3rd level of CORINE Land Cover nomenclature (211, 221, 231, 242, 243, 311, 312, 313, 321, 324, 332 and 333). 179 subkinds landscapes were separated at this level.

The classification of landscape of South Pirin and Slavyanka is presented in Table 1 and the final result is the landscape map of the study area shown on Figure 1.

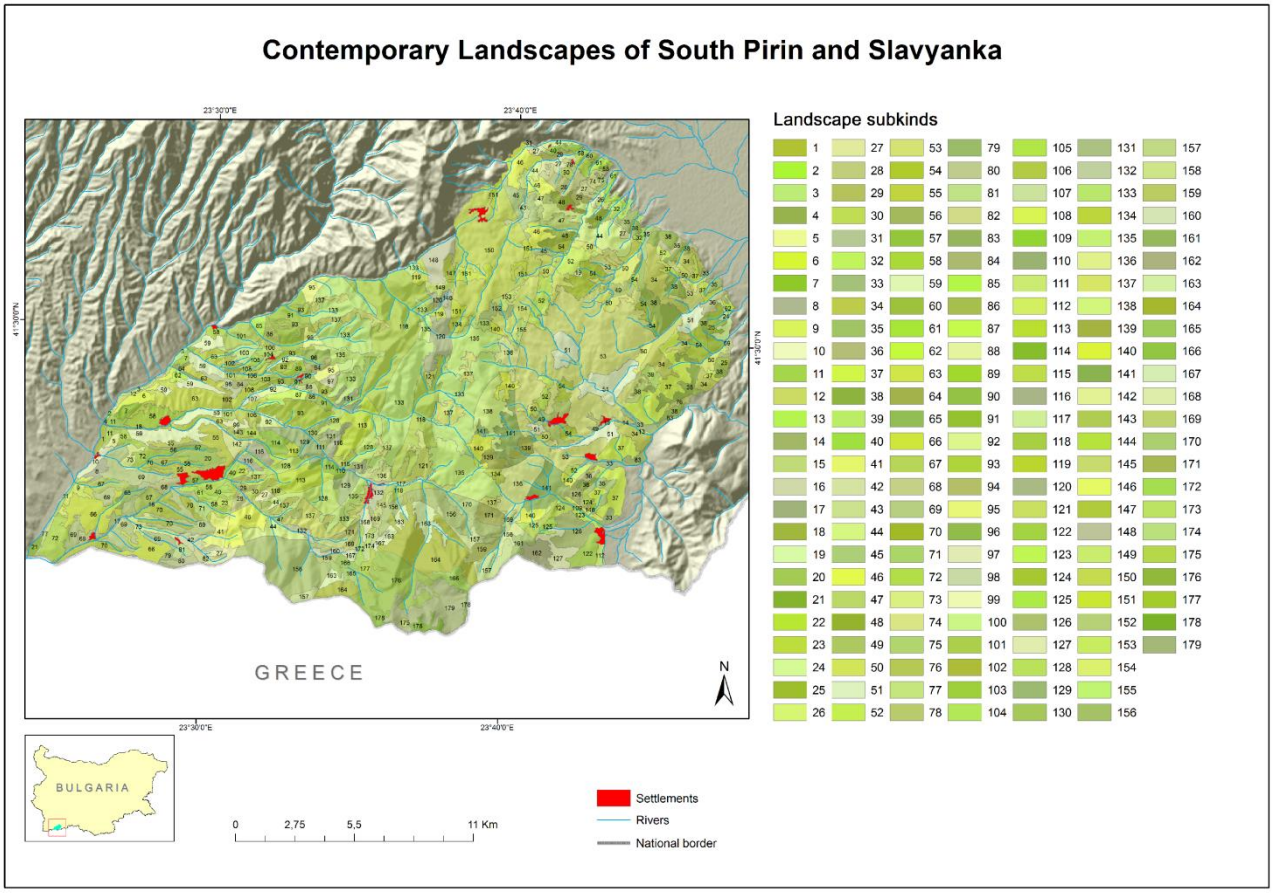

Figure 1. Contemporary landscapes of South Pirin and Slavyanka mountain regions

Table 1. Landscape classification (№ represent the numbers on the map legend in Figure 1)

Landscape	№	Landscape	№
Plains and foothills		**Metamorphic and igneous rocks**	
Mountain-hilly areas		**Chromic Luvisols**	
Hydromorphic and subhydromorphic		Pastures	89
Humid mediterranean with plane tree forests		Land principally occupied by agriculture, with significant areas of natural vegetation	90
Flood-plain and fluvial terrace above flood-plain		Broad-leaved forest	91
Alluvial-deluvium deposits		Mixed forest	92
Dystric/Eutric Fluvisols		Transitional woodland/shrub	93
Non-irrigated arable land	1	**Cambisols**	
Land principally occupied by agriculture, with significant areas of natural vegetation	2	Pastures	94
eroded Chromic Luvisols		Broad-leaved forest	95
Land principally occupied by agriculture, with significant areas of natural vegetation	3	Coniferous forest	96
Chromic Luvisols		Transitional woodland/shrub	97
Land principally occupied by agriculture, with significant areas of natural vegetation	4	**Sedimentary rocks**	
Slope		**eroded Chromic Luvisols**	
Sedimentary rocks		Non-irrigated arable land	98
eroded Chromic Luvisols		Pastures	99
Land principally occupied by agriculture,	5	Land principally occupied by	100

with significant areas of natural vegetation		agriculture, with significant areas of natural vegetation	
Broad-leaved forest	6	Broad-leaved forest	101
Transitional woodland/shrub	7	Transitional woodland/shrub	102
Chromic Luvisols		**Chromic Luvisols**	
Non-irrigated arable land	8	Non-irrigated arable land	103
Land principally occupied by agriculture, with significant areas of natural vegetation	9	Complex cultivation patterns	104
Alluvial-deluvium deposits		Land principally occupied by agriculture, with significant areas of natural vegetation	105
Dystric/Eutric Fluvisols		Broad-leaved forest	106
Vineyards	10	Mixed forest	107
Land principally occupied by agriculture, with significant areas of natural vegetation	11	Transitional woodland/shrub	108
eroded Chromic Luvisols		**Mountain, warm-temporate humid**	
Broad-leaved forest	12	**Medium-height mountain forest**	
Mountain		**Flood-plain and fluvial terrace above flood-plain**	
Mountain, warm-temporate submediterraniean		**Marbles**	
Low-mountain submediterranean forest and shiblyak		**Dystric/Eutric Fluvisols**	
Flood-plain and fluvial terrace above flood-plain		Land principally occupied by agriculture, with significant areas of natural vegetation	109
Marbles		**Chromic Luvisols**	
Rendzic Leptosols		Natural grassland	110
Land principally occupied by agriculture, with significant areas of natural vegetation	13	**Metamorphic and igneous rocks**	
Natural grassland	14	**Chromic Luvisols**	
Metamorphic and igneous rocks		Natural grassland	111
Rendzic Leptosols		**Alluvial-deluvium deposits**	
Land principally occupied by agriculture, with significant areas of natural vegetation	15	**Dystric/Eutric Fluvisols**	
Sedimentary rocks		Non-irrigated arable land	112
Chromic Luvisols		**Slope**	
Pastures	16	**Marbles**	
Land principally occupied by agriculture, with significant areas of natural vegetation	17	**Chromic Luvisols**	
Alluvial-deluvium deposits		Broad-leaved forest	113
eroded Chromic Luvisols		Mixed forest	114
Land principally occupied by agriculture, with significant areas of natural vegetation	18	Natural grassland	115
Denudation surfaces		Transitional woodland/shrub	116
Metamorphic and igneous rocks		**Cambisols**	
Rendzic Leptosols		Land principally occupied by agriculture, with significant areas of natural vegetation	117
Transitional woodland/shrub	19	Broad-leaved forest	118
Sedimentary rocks		Coniferous forest	119
eroded Chromic Luvisols		Mixed forest	120
Non-irrigated arable land	20	Transitional woodland/shrub	121
Alluvial-deluvium deposits		**Rendzic Leptosols**	
Dystric/Eutric Fluvisols		Non-irrigated arable land	122
Land principally occupied by agriculture, with significant areas of natural vegetation	21	Land principally occupied by agriculture, with significant areas of natural vegetation	123
Slope		Coniferous forest	124

Marbles		Mixed forest	125
eroded Chromic Luvisols		Natural grassland	126
Land principally occupied by agriculture, with significant areas of natural vegetation	22	Transitional woodland/shrub	127
Mixed forest	23	**Metamorphic and igneous rocks**	
Chromic Luvisols		**Chromic Luvisols**	
Natural grassland	24	Broad-leaved forest	128
Transitional woodland/shrub	25	Mixed forest	129
Cambisols		Natural grassland	130
Land principally occupied by agriculture, with significant areas of natural vegetation	26	Transitional woodland/shrub	131
Broad-leaved forest	27	**Cambisols**	
Mixed forest	28	Land principally occupied by agriculture, with significant areas of natural vegetation	132
Natural grassland	29	Broad-leaved forest	133
Transitional woodland/shrub	30	Coniferous forest	134
Sparsely vegetated areas	31	Mixed forest	135
Rendzic Leptosols		Natural grassland	136
Pastures	32	Transitional woodland/shrub	137
Land principally occupied by agriculture, with significant areas of natural vegetation	33	**Rendzic Leptosols**	
Broad-leaved forest	34	Broad-leaved forest	138
Coniferous forest	35	Coniferous forest	139
Mixed forest	36	Mixed forest	140
Natural grassland	37	Natural grassland	141
Transitional woodland/shrub	38	**Sedimentary rocks**	
Bare rock	39	**eroded Chromic Luvisols**	
Metamorphic and igneous rocks		Non-irrigated arable land	142
eroded Chromic Luvisols		Transitional woodland/shrub	143
Land principally occupied by agriculture, with significant areas of natural vegetation	40	**Chromic Luvisols**	
Mixed forest	41	Pastures	144
Chromic Luvisols		**Alluvial-deluvium deposits**	
Transitional woodland/shrub	42	**Cambisol**	
Cambisols		Natural grassland	145
Land principally occupied by agriculture, with significant areas of natural vegetation	43	**Rendzic Leptosols**	
Broad-leaved forest	44	Natural grassland	146
Coniferous forest	45	**Mountain, cold-temporate, humid**	
Mixed forest	46	**Medium-height mountain, coniferous**	
Natural grassland	47	**Slope**	
Transitional woodland/shrub	48	**Marbles**	
Rendzic Leptosols		**Cambisols**	
Land principally occupied by agriculture, with significant areas of natural vegetation	49	Broad-leaved forest	147
Broad-leaved forest	50	Coniferous forest	148
Coniferous forest	51	Natural grassland	149
Mixed forest	52	**Metamorphic and igneous rocks**	
Natural grassland	53	**Cambisols**	
Transitional woodland/shrub	54	Coniferous forest	150
Sedimentary rocks		Mixed forest	151
eroded Chromic Luvisols		**Rendzic Leptosols**	
Non-irrigated arable land	55	Broad-leaved forest	152
Vineyards	56	Coniferous forest	153
Complex cultivation patterns	57	Mixed forest	154
Land principally occupied by agriculture, with significant areas of natural vegetation	58	Natural grassland	155

Broad-leaved forest	59	**High-mountain, mainly pine**	
Coniferous forest	60	**Slope**	
Mixed forest	61	**Marbles**	
Natural grassland	62	**Cambisols**	
Transitional woodland/shrub	63	Broad-leaved forest	156
Bare rock	64	Coniferous forest	157
Chromic Luvisols		Mixed forest	158
Non-irrigated arable land	65	Natural grassland	159
Vineyards	66	Transitional woodland/shrub	160
Pastures	67	**Rendzic Leptosols**	
Complex cultivation patterns	68	Coniferous forest	161
Land principally occupied by agriculture, with significant areas of natural vegetation	69	Mixed forest	162
Broad-leaved forest	70	**Umbrosols**	
Mixed forest	71	Broad-leaved forest	163
Natural grassland	72	Coniferous forest	164
Transitional woodland/shrub	73	Mixed forest	165
Cambisols		Natural grassland	166
Complex cultivation patterns	74	Transitional woodland/shrub	167
Land principally occupied by agriculture, with significant areas of natural vegetation	75	**Metamorphic and igneous rocks**	
Rendzic Leptosols		**Cambisols**	
Natural grassland	76	Pastures	168
Alluvial-deluvium deposits		Broad-leaved forest	169
Dystric/Eutric Fluvisols		Mixed forest	170
Natural grassland	77	Transitional woodland/shrub	171
eroded Chromic Luvisols		**Umbrosols**	
Land principally occupied by agriculture, with significant areas of natural vegetation	78	Land principally occupied by agriculture, with significant areas of natural vegetation	172
Chromic Luvisols		**Alluvial-deluvium deposits**	
Vineyards	79	**Cambisols**	
Complex cultivation patterns	80	Pastures	173
Land principally occupied by agriculture, with significant areas of natural vegetation	81	**Umbrosols**	
Transitional woodland/shrub	82	Transitional woodland/shrub	174
Rendzic Leptosols		**High-mountain meadow**	
Land principally occupied by agriculture, with significant areas of natural vegetation	83	**Subalpine dwarf pine and meadow**	
Mountain, warm-temporate semihumid		**Denudation surfaces**	
Transitional to submediterranean, hollow, forest and shiblyak		**Marbles**	
Denudation surfaces		**Umbrosols**	
Sedimentary rocks		Transitional woodland/shrub	175
Chromic Luvisols		**Slope**	
Non-irrigated arable land	84	**Marbles**	
Slope		**Umbrosols**	
Marbles		Coniferous forest	176
eroded Chromic Luvisols		Mixed forest	177
Broad-leaved forest	85	Natural grassland	178
Chromic Luvisols		Transitional woodland/shrub	179
Broad-leaved forest	86		
Mixed forest	87		
Transitional woodland/shrub	88		

CONCLUSIONS

The results of this study show significant landscape diversity in South Pirin and Slavyanka mountainous region in Bulgaria. It should be noted that the majority of the study area is relatively well preserved in natural terms territory, which for the most part is covered by natural landscapes. Also the territory can be considered as relatively less affected area of contemporary manifestations of anthropogenic interference. In the classification that was used for creating this map, the author includes detailed data on land cover and land use, which is performed for the first time in the country for investigating conditional natural territory. Thereby, data for landscapes differentiation with high thematic and spatial accuracy is obtained.

Created landscape map can be used for further studies and to help the decision making process in the region of South Pirin and Slavyanka. Mapping landscape types based on remote sensing and GIS data can support integrated environmental assessment and biodiversity protection, monitoring and management.

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