Recovery

RFCS RESEARCH PROJECT

Recovery of degraded and transformed ecosystems in coal mining-affected areas

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Deliverable 2.8

Assessment of ecosystem services of Ema-Terezie Mine dumps complex

European Commission

Research Fund for Coal & Steel

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Executive summary

Deliverable 2.8. is based on the analysis of CLC classes of the study area Ema – Terezie Mine Dumps Complex (see Deliverable 2.3.). Artificial areas have a significant predominance of over other CLC categories. Forest and semi –natural areas are the second largest category, which corresponds to nature close vegetation on mine dumps.

After analysing CLC classes of the study area, as well as the topography, the following ecosystem services (at the level of classes) were selected as important/representative for Ema-Terezie Mine dumps complex. Each ecosystem service was processed according to the CICES V5.1 Code with the indication of Group, Class code, ES indicator, Method, Reference, Main data sources and Sources of uncertainty:

1. Provisioning services: Food production (Class code 1.1.1.1 Cultivated terrestrial plants for nutrition, materials or energy),
2. Regulating services: Carbon sequestration (Class code 2.2.6.1 Atmospheric composition and conditions); Climate regulation (Class code 2.2.6.2 Atmospheric composition and conditions); Regulation of physical, chemical, biological condition (Class code 2.2.2.3 Lifecycle maintenance, habitat and gene pool protection),
3. Cultural services: Cultural heritage (Class code 3.2.2.1 Other biotic characteristics that have a non-use value).

The evaluation of ecosystem services was carried out using a point scale based on EC indicators. Ecosystem services "Food production", "Climate regulation", "Regulation of physical, chemical, biological condition" and "Cultural heritage" could reach a maximum of 10 points. Ecosystem service "Carbon sequestration" could reach max. of 5 points.

The results of the evaluation of ecosystem services show, that Ema – Terezie Dumps Complex is of great importance in terms of regulating and cultural services, where it achieves a high score.

1 Introduction

Work Package Nº 2 focuses on mapping and assessing the ecosystems and their services of the project's case studies. Specific objectives are:

1. To identify the adequate boundaries of the different case studies based on existing spatial connectivity and functional cohesion for each coal mining-affected area.
2. To delineate, categorize and map the different ecosystems types of land covers in the study areas, according to CORINE Land Cover classes (Bossard et al., 2000; Kosztra et al., 2017), although doing detailed field mapping at a higher resolution.
3. To assess the ecosystem services according to the Common International Classification of Ecosystem Services (CICES) V5.1 (Haines-Young & Potschin, 2018), in order to achieve standardization and to avoid any overlapping or redundancy within the different categories.
4. To implement a geographic information system (GIS) web interface for each-case study, allowing constructing user desired information thematic maps for viewing purposes.

As the typology of ecosystems and ecosystem services will provide the analytical frame for the project, in order to operationalize this work package, after Task 2.1 that was focused on the baseline mapping of relevant ecosystems, Task 2.2 will focus on the assessment of ecosystem services.

In order to achieve the higher degree of standardization and to avoid any overlapping or redundancy within the different categories, the hierarchical structure of the Common International Classification of Ecosystem Services (CICES) V5.1 will be used to assess the ecosystem services of each case study, that is "the benefits people obtain from ecosystems" (Millennium Ecosystem Assessment, 2005).

For each relevant land cover the three main section categories (provisioning services, regulating and maintenance services, and cultural services) will be considered, both biotic and abiotic, divided into main types of output or process (Division).

After that, the main types of output or process will be divided into group levels, according to the biological, physical or cultural type or process, and sub-divided into class categories, that are codified in CICES. Class types within class categories will allow to link ecosystem services with identifiable services, suggesting ways of measuring the associated ecosystem services output.

Deliverable 2.8 will undergo the assessment of ecosystem services of Ema-Terezie Mine dumps complex, property of RPG RE Land, Ltd. Ostrava (Czech Republic).

2 Assessment of representative ecosystem services for Ema-Terezie Mine dumps complex

Figure 2-1 presents CORINE Land Cover classes in Ema-Terezie Mine dumps complex, and Figure 2-2 presents CLC classes in Ema-Terezie Mine dumps complex over the Orthoimage of the area.

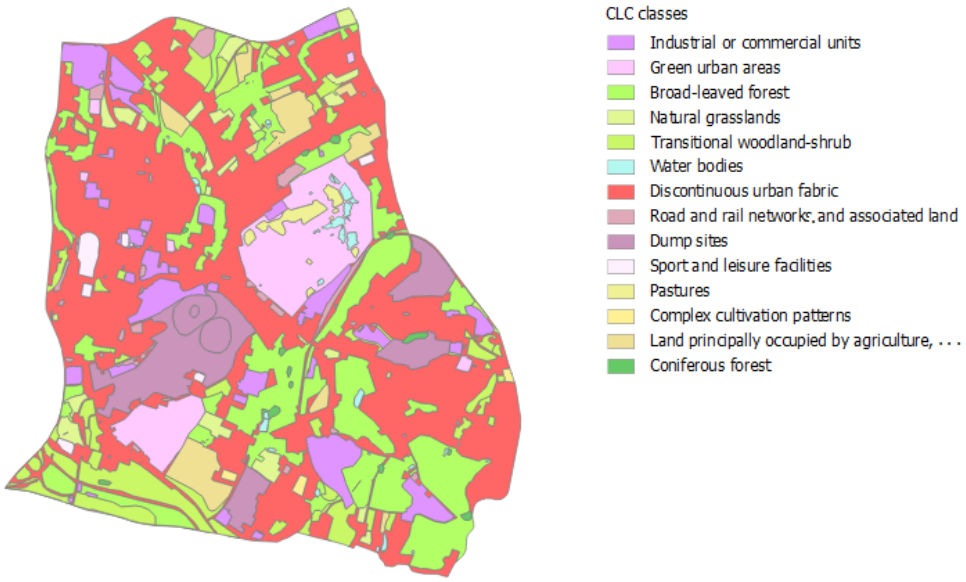


Figure 2-1. CORINE Land Cover classes in Ema-Terezie Mine dumps complex

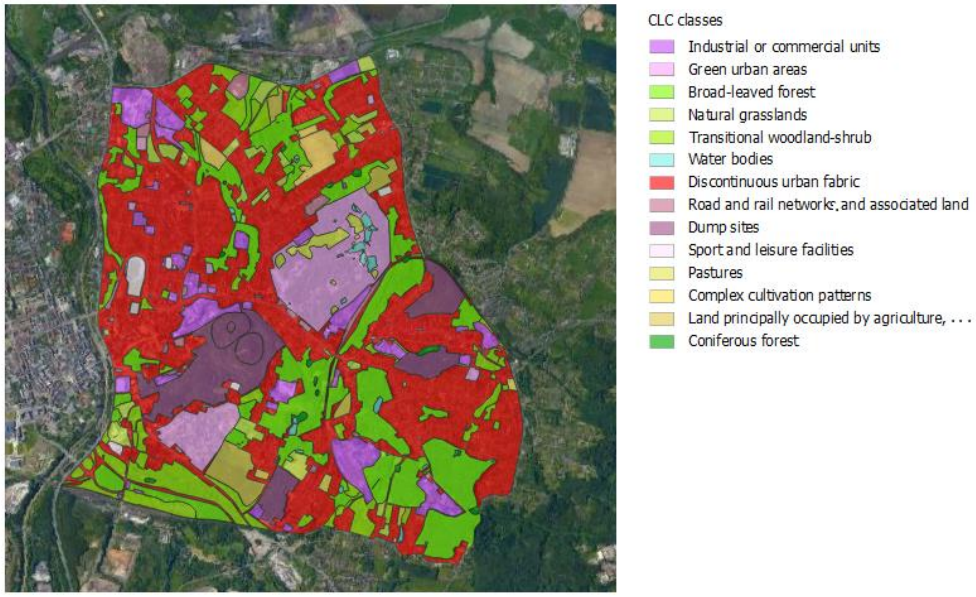


Figure 2-2. CLC classes in Ema-Terezie Mine dumps complex over the orthoimage of the area

Figure 2-3 presents a 3D image of the study area with the CLC classes over impressed.

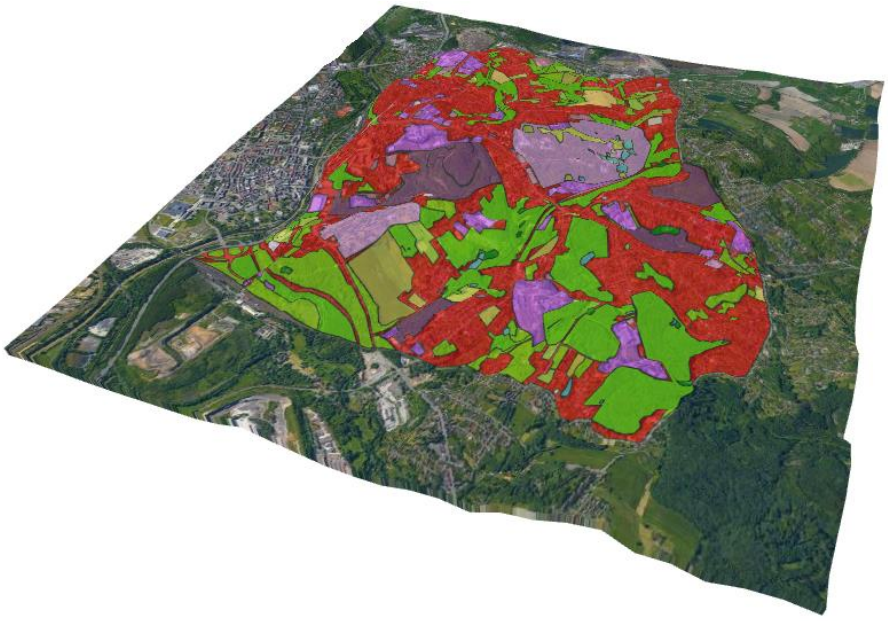


Figure 2-3. 3D image of the CLC classes

Figure 2-4 presents the spider graph of the CLC classes for Ema-Terezie Mine dumps complex, with a significant predominance of artificial areas over other CLC categories. The second largest category are forest and semi –natural areas, which corresponds to nature close vegetation on mine dumps.

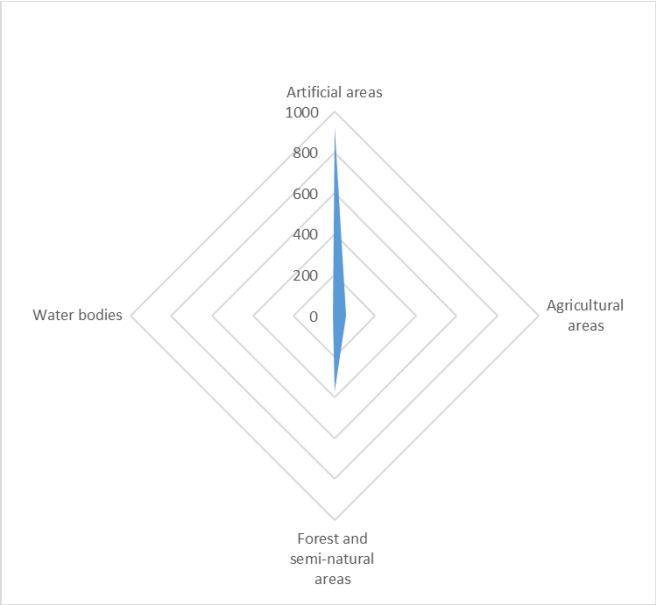


Figure 2-4. Spider graph of CLC classes for Ema-Terezie Mine dumps complex (ha)

After analysing CLC classes of the study area, as well as the topography, the following ecosystem services (at the level of classes) were selected as important/representative for Ema-Terezie Mine dumps complex, with indication of the CICES V5.1 code.

2.1 PROVISIONING SERVICES: FOOD PRODUCTION

Food provision is delivered in the Ema-Terezie mine dump case-study in Complex cultivation patterns and Land principally occupied by agriculture. Pastures are used only extensively; their livestock production is not known.

Group: Cultivated terrestrial plants for nutrition, materials or energy
Class code: 1.1.1.1.
ES indicator: Surface area of organic crops (ha)
Method: Surface area with potential to grow organic crops (ha)
Reference: Mapping and Assessment of Ecosystems and their Services: Trends in ecosystems and ecosystem services in the European Union between 2000 and 2010. (Maes et al. 2015).
Main data sources: GIS results from Deliverables 2.3.
Sources of uncertainty: changes in agricultural area as a result of changes in ownership and land use.

Table 2-1 presents evaluation of food production in solved area.

Table 2-1. Evaluation of food production in solved area

CORINE land cover 3	ha	Scale
Pastures	8,90	5
Complex cultivation patterns	2,84	10
Land principally occupied by agriculture, with significant areas of natural vegetation	45,08	10
Other parts of study area		0

Figure 2-5 presents provisioning service Food production in Ema-Terezie Mine dumps complex.

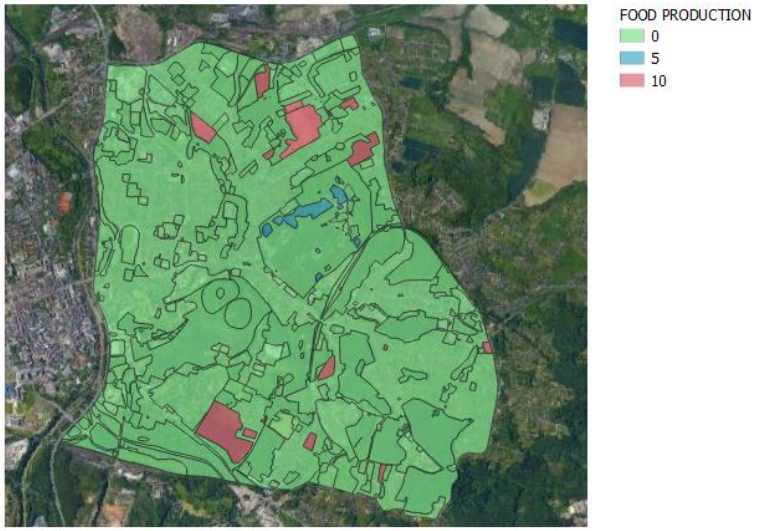


Figure 2-5. Provisioning services: Food production

2.2 REGULATING SERVICES: CARBON SEQUESTRATION

Carbon sequestration is delivered in the Ema-Terezie mine dump study-case by Broad-leaved forest, Dump sites, Green urban areas, Transitional woodland/shrubs and Natural grasslands. CLC Discontinuous urban fabric plays an important role due to large area.

Group: Atmospheric composition and conditions
Class code: 2.2.6.1
ES indicator: Above-ground carbon storage ha^{-1}
Method: Above-ground carbon storage linked to land use [MgC/ha]
Reference: Above-ground carbon storage by urban trees in Leipzig, Germany: Analysis of patterns in a European city (Strohbach and Haase 2012).
Main data sources:

- Carbon accumulation in Finland's forests 1922-2004 - An estimate obtained by combination of forest inventory data with modelling of biomass, litter and soil (Liski et al. 2006).
- EU Emissions Trading System (EU ETS).
- GIS results from Deliverables 2.3.

Valuation by direct methods (e.g. market prices): Valuation by indirect methods (e.g. avoided damage cost, repair cost, replacement cost).
Sources of uncertainty Assessment: Differing values in different climatic settings/conditions, Modelling assumptions (reduction of complexity at expense of exactness), fluctuating CO_2 production from thermal processes (burning inside the heap)
Valuation: Valuation is based on effects of lack of regulating service (assumptions of transformation, reduction of complexity of cause-effect relationships).

Table 2-2 presents evaluation of Carbon sequestration in solved area.

Table 2-2. Evaluation of carbon sequestration in solved area

CORINE land cover 3	Carbon sequestration [Mg C ha−1]	Scale
Coniferous forest	72.91±3.26	5
Dump sites	68.31±12.63**	5
Broad-leaved forest	68.31±12.63	5
Green urban areas	29.38±11.41***	4
Discontinuous urban fabric	20.0±9.4*	3
Natural grasslands	13.48 ±4.49	3
Transitional woodland-shrub	10.12±2.93	2
Industrial or commercial units	8.52±7.78	1
Road and rail networks and associated land	8.52±7.78	0
Sport and leisure facilities	20.0±9.4***	3
Pastures	20.0±9.4*	3
Complex cultivation patterns	8.52±7.78***	1
Land principally occupied by agriculture, with significant areas of natural vegetation	10.12±2.93***	2
Water bodies	-	0

*Discontinuous urban fabric=mixed urban fabric in M.W. Strohbach, D. Haase, 2012
**Dump sites = Broad-leaved forest, M.W. Strohbach, D. Haase, 2012 do not describe this category, most similar in terms of biotope
*** Determined approximately by physiognomically or ecologically similar CLC level

Figure 2-6 presents regulation service Carbon sequestration in Ema-Terezie Mine dumps complex.

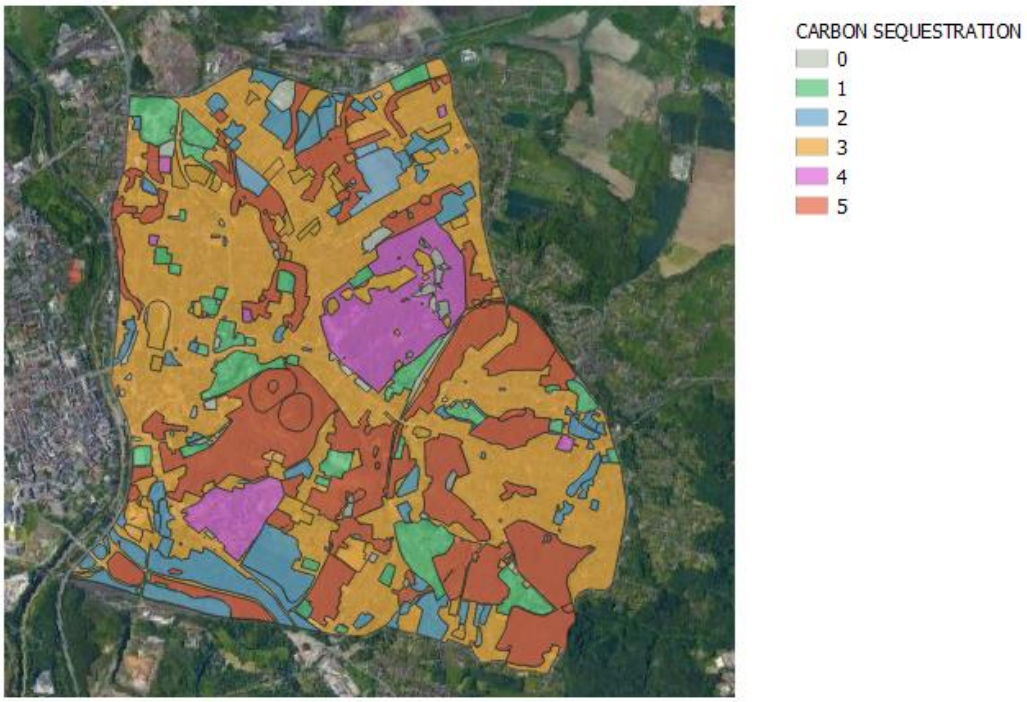


Figure 2-6. Regulating services: Carbon sequestration

2.3 REGULATING SERVICES: CLIMATE REGULATION

Climate regulation is delivered in the Ema-Terezie mine dump case-study by Broad-leaved forest (included mine dump sites), Green urban areas, Pastures, Transitional woodland/shrubs and Natural Grassland.

Group: Atmospheric composition and conditions
class code: 2.2.6.2
ES indicator: Thermal emissivity
Method: Summaries means thermal emission for all land cover classes from Landsat Thermal and Surface Emissivity (Landsat8 – band10).
Reference:

- Assessing climate impacts of planning policies - An estimation for the urban region of Leipzig (Germany). Environmental Impact Assessment Review (Schwarz et al. 2011)
- Effects of urbanisation on the water balance - A long-term trajectory (Haase 2009)

Valuation by indirect methods (e.g. avoided damage cost, repair cost, replacement cost).
Main data sources:

- Landsat Thermal and Surface Emissivity – band 10 (31.8.2019)
- GIS results from Deliverables 2.3.

Sources of uncertainty: **Assessment**: Differing values in different climatic settings/conditions, Modelling assumptions (reduction of complexity at expense of exactness).
Valuation: Valuation is based on effects of lack of regulating service (assumptions of transformation, reduction of complexity of cause-effect relationships)

Table 2-3 presents evaluation of Thermal emissivity in solved area.

Table 2-3 Evaluation of thermal emissivity in solved area

	Thermal emissivity (31.8.2019)				
CORINE land cover 3	**Mean**	**St_dev**	**Max**	**Min**	**Scale**
Coniferous forest	26576.9	262.3	26207	27241	10
Dump sites	26540.0	267.7	26150	27878	10
Broad-leaved forest	26624.6	359.6	26050	28295	10
Green urban areas	26623.2	356.4	26092	28053	10
Discontinuous urban fabric	27393.8	412.7	26147	28935	3
Natural grasslands	27085.2	393.1	26301	28537	6
Transitional woodland-shrub	26914.9	384.0	26168	28369	7
Industrial or commercial units	27768.6	575.2	26288	29032	0
Road and rail networks and associated land	27565.4	484.3	26266	28867	1
Sport and leisure facilities	27704.4	400.6	26926	28345	0
Pastures	26881.1	194.5	26263	27211	7
Complex cultivation patterns	27300.9	216.3	26869	27763	4
Land principally occupied by agriculture, with significant areas of natural vegetation	27508.4	920.1	26348	29426	2
Water bodies	26540.6	219.9	26193	27157	10

Figure 2-7 presents regulation service Climate regulation in Ema-Terezie Mine dumps complex.

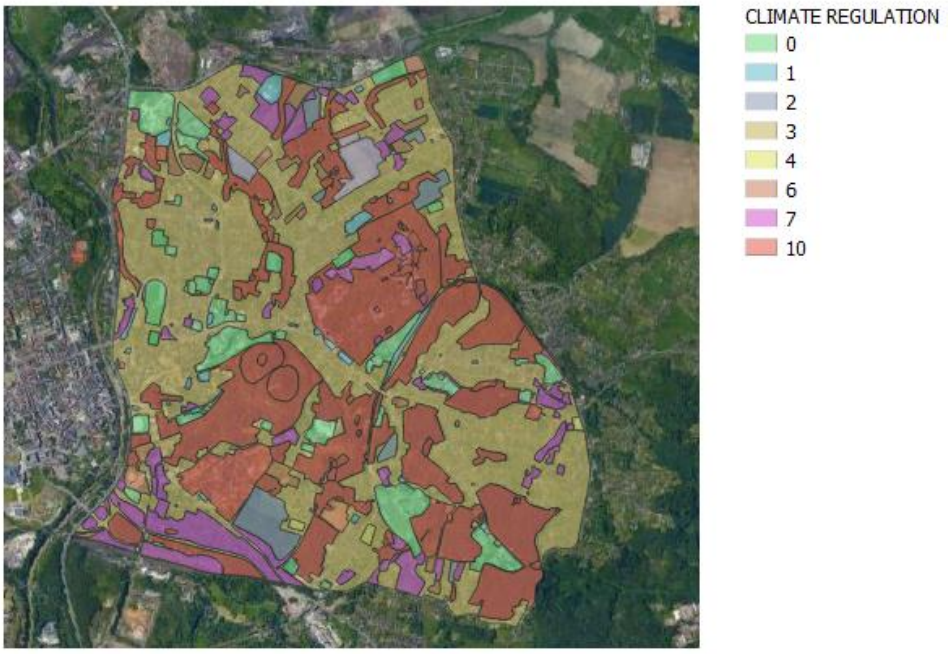


Figure 2-7. Regulating services: Regulation of temperature

2.4 REGULATING SERVICES: PHYSICAL, CHEMICAL, BIOLOGICAL CONDITION

Maintaining rare populations and habitats (Including gene pool protection) in the Ema-Terezie mine dump case study due to protected and iconic plant species (for example *Quercus cerris, Pyrola minor, Hacquetia epipactis, Chenopodium botrys*) and animal species (for example *Bombina bombina, Bombina variegata, Anguis fragilis, Emberiza citrinella, Dendrocopos minor*).

Group: Lifecycle maintenance, habitat and gene pool protection
Class: 2.2.2.3
ES indicator: Number of rare species
Method: Occurrence and abundance of rare plant and animal species
Reference: Perspectives on the link between ecosystem services and biodiversity: The assessment of the nursery function (Liquete et al. 2016).
Main data sources:

- Červený seznam ohrožených druhů České republiky. Cévnaté rostliny. Red List of Threatened Species of the Czech Republic. Vascular Plants. (Grulich and Chobot 2017) - Act no. 114/1992 Coll., on the Protection of nature and landscape protection
- GIS results from Deliverables 2.3.
- Field survey of authors

Valuation by indirect methods: (e.g. stated or revealed preference, etc.).
Sources of uncertainty: Unfinished field survey

Table 2-4 presents evaluation of rare species in solved area.

Table 2-4. Evaluation of rear species in solved area

CLC3 or Area	Scale
ZOO	10
Coniferous forest	3
Dump sites	7
Broad-leaved forest	7
Green urban areas	1
Discontinuous urban fabric	3
Natural grasslands	3
Transitional woodland-shrub	3
Industrial or commercial units	0
Road and rail networks and associated land	0
Sport and leisure facilities	0
Pastures	1
Complex cultivation patterns	0
Land principally occupied by agriculture, with significant areas of natural vegetation	1
Water bodies	1

Figure 2-8 presents regulation service Rare species in Ema-Terezie Mine dumps complex.

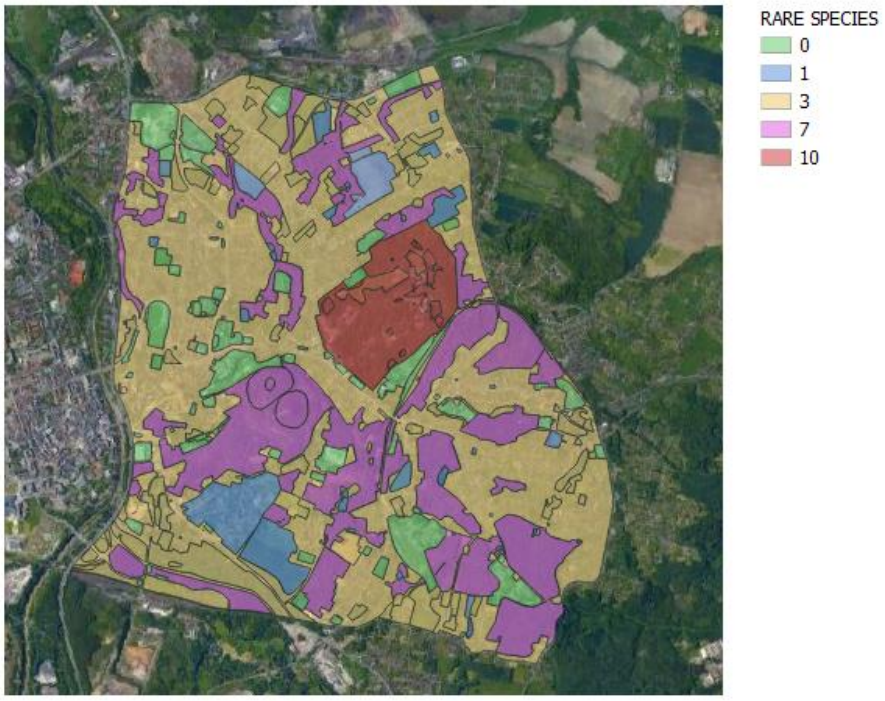


Figure 2-8. Regulating services: Rare species

2.5 CULTURAL SERVICES: CULTURAL HERITAGE

The biophysical characteristics or qualities of species or ecosystems (landscapes) which people seek to preserve for future generations for whatever reason: in this case, the conservation and protection of typical ecosystems bound to thermally active black coal mine dumps with the occurrence of thermophilic fauna and flora species.

Group: Other biotic characteristics that have a non-use value
Class: 3.2.2.1
ES indicator: Number of visitants.
Method: Number of visitants per year.
Reference: Mapping ecosystem service capacity, flow and demand for landscape and urban planning: A case study in the Barcelona metropolitan region. Land Use Policy. (Baró et al. 2016).
Main data sources:

- Návštěvnost turistických aktraktivit lame rekordy (Havránek 2020)
- Návštěvnost turistických cílů 2017 (Institut turismu 2018)
- Návštěvnost památek v krajích ČR v roce 2016-2018 (Národní informační a poradenské středisko 2019)
- Jaký byl rok v 2018 v ZOO Ostrava (ZOO Ostrava 2019)
- GIS results from Deliverables 2.3.

Valuation by indirect methods: (e.g. stated or revealed preference, etc.).
Sources of uncertainty Assessment: definition of ES is closely connected to cultural values.
Valuation: Valuation is based on cultural values, which are to certain, extend subjective, and based on the cultural background of the stakeholders.

Table 2-5 presents evaluation of Number of visitants per year in solved area.

Table 2-5. Evaluation of number of visitants per year in solved area

Area	Number of visitants year^{-1} (2018)	Scale
ZOO	537412	10
Slezskoostravský Castle	113176	8
Mine dump Ema - Terezie, Trojice valley	100000	8
Bazaly – sport center		4
Michal Mine (cultural monument)	6708	2
Other parts of study area		0

Figure 2-9 presents cultural service Number of visitors in Ema-Terezie Mine dumps complex.

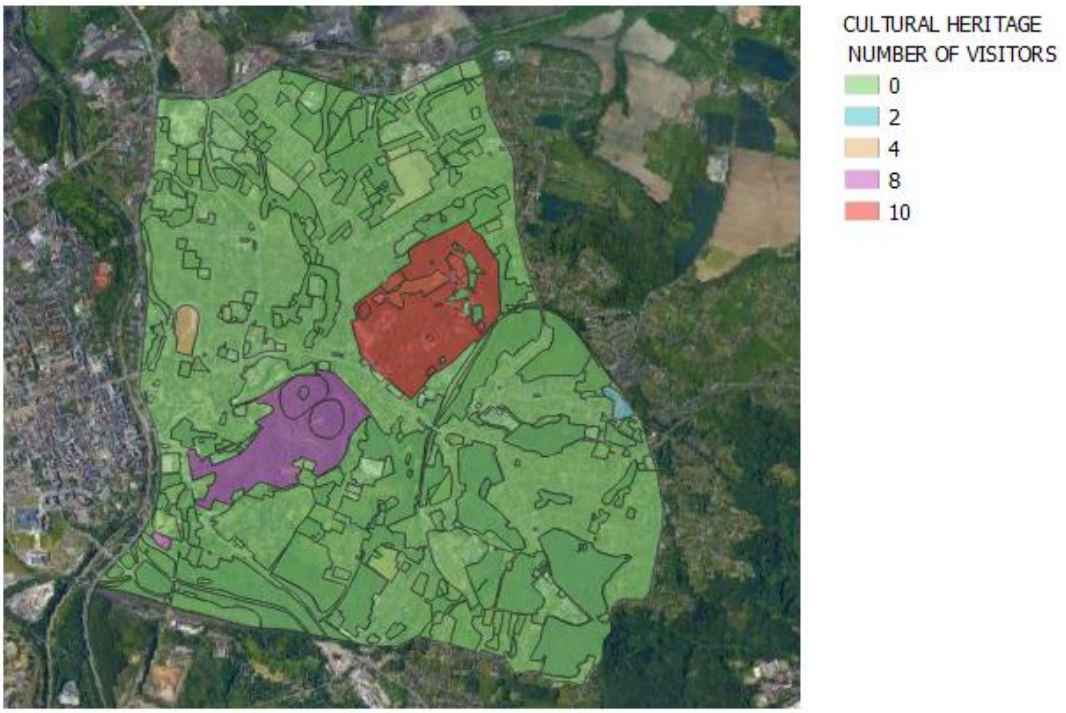
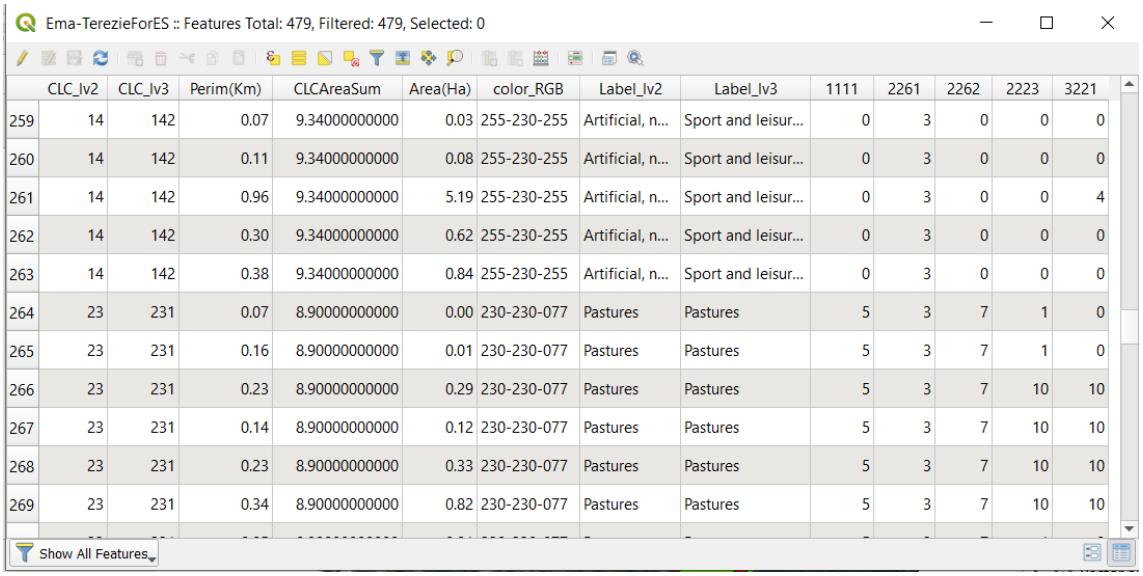


Figure 2-9. Cultural services: Cultural heritage – Number of visitants

Figure 2-10 presents filled attributes in GIS layer for Ema-Terezie Mine dumps complex case study.



Ema-TerezieForES :: Features Total: 479, Filtered: 479, Selected: 0

	CLC_lv2	CLC_lv3	Perim(Km)	CLCAreaSum	Area(Ha)	color_RGB	Label_lv2	Label_lv3	1111	2261	2262	2223	3221
259	14	142	0.07	9.34000000000	0.03	255-230-255	Artificial, n...	Sport and leisur...	0	3	0	0	0
260	14	142	0.11	9.34000000000	0.08	255-230-255	Artificial, n...	Sport and leisur...	0	3	0	0	0
261	14	142	0.96	9.34000000000	5.19	255-230-255	Artificial, n...	Sport and leisur...	0	3	0	0	4
262	14	142	0.30	9.34000000000	0.62	255-230-255	Artificial, n...	Sport and leisur...	0	3	0	0	0
263	14	142	0.38	9.34000000000	0.84	255-230-255	Artificial, n...	Sport and leisur...	0	3	0	0	0
264	23	231	0.07	8.90000000000	0.00	230-230-077	Pastures	Pastures	5	3	7	1	0
265	23	231	0.16	8.90000000000	0.01	230-230-077	Pastures	Pastures	5	3	7	1	0
266	23	231	0.23	8.90000000000	0.29	230-230-077	Pastures	Pastures	5	3	7	10	10
267	23	231	0.14	8.90000000000	0.12	230-230-077	Pastures	Pastures	5	3	7	10	10
268	23	231	0.23	8.90000000000	0.33	230-230-077	Pastures	Pastures	5	3	7	10	10
269	23	231	0.34	8.90000000000	0.82	230-230-077	Pastures	Pastures	5	3	7	10	10

Show All Features

Figure 2-10. Attributes table of the Ema-Terezie Mine dumps complex case study

3 Conclusions and lessons learnt

For the purpose of assessment of ecosystem services for Ema-Terezie area identified environmental impacts of mine dumps complex were analysed. Taking into consideration different ways of post mining revitalization five ecosystem services for Ema-Terezie mine dumps complex were selected i.e. three regulating, one cultural and one provisioning.

Ecosystem services were found in the model area:

- Provisioning services: Food productions
    - 1.1.1.1. Cultivated terrestrial plants for nutrition, materials or energy (pastures 8,9 ha, Complex cultivation patterns 2,84 ha, Land principally occupied by agriculture, with significant areas of natural vegetation 45,08 ha)
- Regulating services: Carbon sequestration
    - 2.2.6.1. Atmospheric composition and conditions
- Regulating services: Climate regulation
    - 2.2.6.2. Atmospheric composition and conditions
- Regulating services: Regulation of physical, chemical and biological conditions
    - 2.2.2.3. Lifecycle maintenance, habitat and gene pool protection
- Cultural services: Cultural Heritage
    - 3.2.2.1. Other biotic characteristics that have a non-use value

Ema-Terezie district area is significantly impacted by mining activity and the mine dumps complex itself has a negative influence on ecosystem services output i.e. negative impact on biodiversity. On the other hand, a response on the impact is able to increase the potential of different services that in non-mining areas would be limited or event not possible. When comparing Ema-Terezie mine dumps complex area to CLC classes have low ability to deliver different ecosystem services mentioned before. When analysing other services, it seems that the mine dumps complex could increase potential to deliver services like maintaining rare populations and habitats or cultural heritage. These services have in fact monetary value and could mitigate environmental impacts or increase other negative influences (i.e. acid drainage generation).

Concerning the interrelation between ecosystem services in mining impacted areas it is important to note that different restoration or rehabilitation scenarios could generate new potential of ecosystems to provide high quality services. The ecosystem services concept and their assessment will be applied to different restoration activities and different future redevelopment scenarios for case study landscape. This approach will allow comparing scenarios in the terms of the potential to provide the most favourable ecosystem services.

4 GLOSSARY

CICES - Common International Classification of Ecosystem Services

CLC - CORINE Land Cover

CORINE - Coordination of information on the environment

EEA - European Environment Agency

ES – Ecosystem Service

GIS - Geographic information system

SEEA - System of Environmental and Economic Accounting

UNSD - United Nations Statistical Division

VSB-TU Ostrava – Vysoká škola báňská – Technická universita Ostrava

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