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

847205-RECOVERY-RFCS-2018

Deliverable 3.6

Assessment of scenarios for Ema-Terezie Mine dumps complex

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Deliverable 3.4	
Due date of Deliverable	30.09.2021
Start - End Date of Project	01.07.2019 – 30.06.2023
Duration	4 years
Deliverable Lead Partner	UNIOVI
Dissemination level	Public
Work Package	WP 3
Digital File Name	D3.6 Assessment of scenarios for Ema – Terezie Mine dump complex
Keywords	Assessment, scenarios, planning, Ema – Terezie mine dump complex

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Executive Summary

For assessing Ema - Terezie Mine dump complex scenarios, a workshop for selecting the different types of land rehabilitation and ecosystem restoration actions proposed to generate different scenarios in mining-affected areas was developed. It took place on May the 25th, 2021, during the 6th Microsoft TEAMS meeting of the Recovery Project.

Particular emphasis was given to consultation with stakeholders (local authorities, coal mining industry, trade unions, environmental NGOs, university students and public) to guarantee the success of the whole process. Each partner was responsible for the involvement of stakeholders from his case-study areas.

Among the different actions that can be considered to recover the site, the following six alternatives were considered as the most feasible, taking into consideration Ema - Terezie Mine dump complex features and stakeholders consultation: Other restoration - housebuild, industry and market areas (Buildings); Other restoration - horse trails around riding hall for active recreation (HorseTrail); Agricultural restoration - flowery meadow and pastures (Pastures); Other restoration - natural and controlled succession (Natural); Other restoration - area for animal wildlife and wild-groving plants (WildAnimal); and Forest park, city wildness, workout areas (ForestPark).

These alternatives were introduced in the Smic Prob-Expert tool as the hypothesis to develop the scenario assessment with the opinions of three groups of experts: Owners, Municipalities, Public. As a result of the evaluation processing in the Smic Prob-Expert tool we received list of most suitable combination of hypotheses. The high score with the higher probabilities were: Urban wildness (non-intervention); Wild Animal; and Combination of Building, Horse Trail, Pastures and Forestpark.

Next, a narrative for each selected scenario was developed, including an overall vision for the new post-mining region and some clear targets. Narratives were later translated into change rules for CLC land use classes with the if-then-else mode.

Finally, one map per scenario was developed in order to expand the GIS web interface.

1 Introduction

Work Package Nº 3 focuses on the generation of scenarios for each case-study, in order to enable the analysis of changes in services delivery which are required for quantifying trade-offs among them. Specific objectives are:

1. To develop a blueprint instrument/indicator for both coal mining impact assessment and post-mining landscape (e)valuation: a feasible ex-ante impact assessment planning instrument to make recommendations for future planning and development of post-mining landscapes.
2. To develop artificial substitutes for soils suitable to several types of plant communities that provide a wide range of ecosystem services, addressing "difficult terrains" in coal mining waste heaps.
3. To propose suitable land rehabilitation techniques that allow successful environmental and vegetal developments in coal mining waste heaps.
4. To formulate alternative land rehabilitation and ecological restoration actions for the case-studies, with special emphasis on stakeholder consultation, in order to guarantee the success of the scenario's generation process.
5. To map and quantify the new ecosystem services provision of the different scenarios.
6. To expand the GIS web interface with the different scenarios. In order to achieve the higher degree of standardisation and to avoid any overlapping or redundancy within the different categories, the hierarchical structure of the Common

The importance of using scenarios in ecosystem services assessments is beginning to be realised, as early assessments presented a static picture in a changing world.

The necessity of providing counter-facts is now being demanded in conservation research and will become the norm in ecosystem services research as well.

The generation of different con- and diverging scenarios is particularly important for monetary valuation, since scenarios enable the analysis of changes in services delivery which are required for quantifying trade-offs among them.

Within this task, and leaded by GIG, alternative land rehabilitation and ecological restoration actions were defined for Figaredo Mine (UNOVI-HUNOSA), Janina Mine (GIG-TWD), Chabařovice Mine and Most-Ležáky Mine (VŠB-PKÚ), and Ema - Terezie mine dumps complex (VŠB).

Considering the recommendations for future planning and development of the post-mining landscape from the blueprint instrument/indicator with the cooperation of UBER, as well as the need to improve socio-economic outcomes and to catalyse the development of new jobs, different types of land rehabilitation and ecosystem restoration actions will be proposed in order to generate different scenarios, e.g.:

1. Recolonization of the site by local vegetation.
2. Commercial forestry plantations and secondary forests using local plant species.
3. Development for agriculture (arable land and pasture).
4. Installations for leisure and recreational purposes.
5. Space for wildlife and nature conservation including forms of “bad land sites”.
6. Development of artificial water bodies, e.g., reservoirs, streams, cascades, etc.

Special emphasis was given to consultation of scenarios with stakeholders (local authorities, neighbourhood associations, coal mining industry, trade unions environmental NGOs and students), in order to guarantee the success of the whole process.

Each partner was responsible for the involvement of stakeholders from his case-study areas.

Finally, the new ecosystem services provision of each generated scenario will be mapped and quantified, in order to enable the analysis of changes in services delivery which are required for quantifying trade-offs among them.

The energetic valorisation of mining wastes, the extraction of valuable substances, or its use in the process of obtaining crushed road and construction aggregates, natural aggregates, raw materials for the cement industry, void backfilling, etc., will not be considered, as these valorisation processes are previous to the development of any land rehabilitation and ecological restoration action.

Deliverable 3.6 will undergo the assessment of scenarios for Ema - Terezie Mine complex, property of ASENTAL Group in Czech Republic.

2 Assessment of scenarios for Ema – Terezie Mine complex

To create suitable scenarios, VŠB - TU Ostrava prepared 8 alternatives for future planning and development of Ema - Terezie Mine dump complex (see Figure 2-1). Particular emphasis was given to consultation of alternatives and subsequent scenarios with stakeholders (representatives of municipality, representatives of mining industry, professional public, environmental NGOs and landowners) to guarantee the success of the whole process.

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Alternatives for future planning and development of the landscape after mining to generate of different types of scenarios

Ema - Trojické údolí – Terezie Mine dump complex

Alternative		Description, conditions
1.	Other reclamation - areas for the settlements renewal and new construction	Reclamation through development of family houses and infrastructure, suitable in the marginal flat parts of the Trojice Valley, in connection with the area of the Trojice mine and coke plant
2.	Other reclamation - hippodromes around the riding school for active recreation	In connection with the riding school, recreation, hippotherapy
3.	Agricultural reclamation - flowery meadows and pastures	Fragments in the Trojice Valley, at the foot of the Emma and Terezie dumps, once mowed meadows, pastures with goat grazing, biological significance - entomofauna, extensive economic function, ecological function
4.	Other reclamation - Natural regeneration - spontaneous, or controlled succession	Non-intervention alternative, urban wilderness Ecological function
5.	Other reclamation - space for wild fauna and wild plants	Biological reclamation with recreational use - birdwatching and insect watching, educational function, ecological function
6.	Industrial areas and commercial facilities	Areas of the former Trojice and Petr Bezruč mines, economic function
7.	Forest reclamation - forest park with park equipment for active sports use	park equipment - public lighting, benches, rubbish bins, workout playground, etc. active recreation, in connection with the existing nature trail, recreational functions
8.	Agricultural reclamation - plantations for biomass	Areas for growing alternative energy sources - fast-growing woody plants and herbs - economic function

Scenarios can be created by combinations of alternative solutions according to the opinions of experts and stakeholders.

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Questionnaire

regarding the future use of the territory Ema – Terezie Mine dump complex

State on a scale from 0 (unacceptable variant) to 5 (optimal variant) the evaluation of the alternative of future planning and development of the post-mining landscape of the Ema – Terezie Mine dump complex (8 alternatives in total).

	0	1	2	3	4	5
Alternative 1						
Alternative 2						
Alternative 3						
Alternative 4						
Alternative 5						
Alternative 6						
Alternative 7						
Alternative 8						

Figure 2-1. Alternatives and questionnaire for the basic hypothesis creating

The following six alternatives were considered as the most usable by the VŠB – TU Ostrava, Slezská Ostrava municipality, DIAMO, state enterprise, Czech Union of Nature Conservationists and landowner Asental Group: 1. Other restoration - housebuild industry and market areas; 2. Other restoration - horse trails around riding hall for active recreation; 3. Agricultural restoration - flowery meadow and pastures; 4. Other restoration - natural and controlled succession, 5. Other restoration - area for animal wildlife; 6. Forest park, city wildness, workout areas.

These alternatives were introduced in the Smic Prob-Expert tool as the hypothesis to be used for developing the scenario assessment (Figure 2-2).

#	Long label	Short label
1	Other restoration - housebuild, industry and market areas	Buildings
2	Other restoration - horse trails around riding hall for active recreation	HorseTrail
3	Agricultural restoration - flowery meadow and pastures	Pastures
4	Other restoration - natural and controlled succession	Natural
5	Other restoration - area for animal wildlife and wild-groving plants	WildAnimal
6	Forest park, city wildness, workout areas	ForestPark

Figure 2-2. Hypothesis list (the short label corresponds to the name given to the scenario)

After this, the first step was to define the "simple probabilities of hypotheses". For this purpose, three groups of experts have formed: the VŠB – TU Ostrava (group Public in the Smic Prob Expert programme), Slezská Ostrava Municipality, DIAMO, public enterprise, Czech Union of Nature Conservationists (group Municipal in the Smic Prob Expert programme) and Asental Group (group Owners in the Smic Prob Expert programme). In the second place, the expert groups defined the "conditional probabilities of hypotheses, if other hypotheses are realised". The "conditional probabilities of hypotheses, if other hypotheses are non-realise" were defined in the third place. Figure 2-3 shows the conditional probabilities if realisation from VŠB – TU Ostrava and Figure 2-4 shows these probabilities for all expert groups.

	Buildings	HorseTrail	Pastures	Natural	WildAnimal	ForestPark
1 : Buildings	0,253	0,02	0,015	0,005	0,009	0,023
2 : HorseTrail	0,042	0,234	0,034	0,009	0,007	0,03
3 : Pastures	0,038	0,038	0,227	0,029	0,008	0,024
4 : Natural	0,02	-0,033	0,011	0,153	0,029	0,001
5 : WildAnimal	-0,002	-0,011	-0,011	0,008	0,202	-0,022
6 : ForestPark	0,06	0,043	0,032	0,02	-0,01	0,215

Figure 2-3. Conditional probabilities if realisation from VŠB – TU Ostrava

	Buildings	HorseTrail	Pastures	Natural	WildAnimal	ForestPark
1 : Buildings	0,285	0,02	0,022	0,009	0,015	0,029
2 : HorseTrail	0,084	0,246	0,073	0,038	0,04	0,069
3 : Pastures	0,09	0,075	0,27	0,032	0,055	0,063
4 : Natural	0,026	0,015	0,015	0,241	0,058	0,022
5 : WildAnimal	0,054	0,028	0,039	0,067	0,281	0,033
6 : ForestPark	0,027	0,015	0,015	0,005	0,007	0,244

Figure 2-4. Conditional probabilities if realisation (all expert groups)

After conditional and straightforward probabilities were introduced in the tool, it was possible to determine the probability of all the possible scenarios. The objective of Smic Prob-Expert is to calculate scenario probabilities created according to defined hypotheses.

The probability of each scenario is calculated for every expert via a quadratic minimisation method. Results are also available by expert groups or experts and are calculated with mean weighted probabilities determined for each expert. The Smic Prob-Expert method transforms defined hypotheses probabilities by experts to coherent data, in other words respecting the basic probabilities' formulae. Net data computed by the software will hence replace the raw data provided by experts. Figure 2-5 presents the histogram of 8 the most likely scenarios according to all the experts.

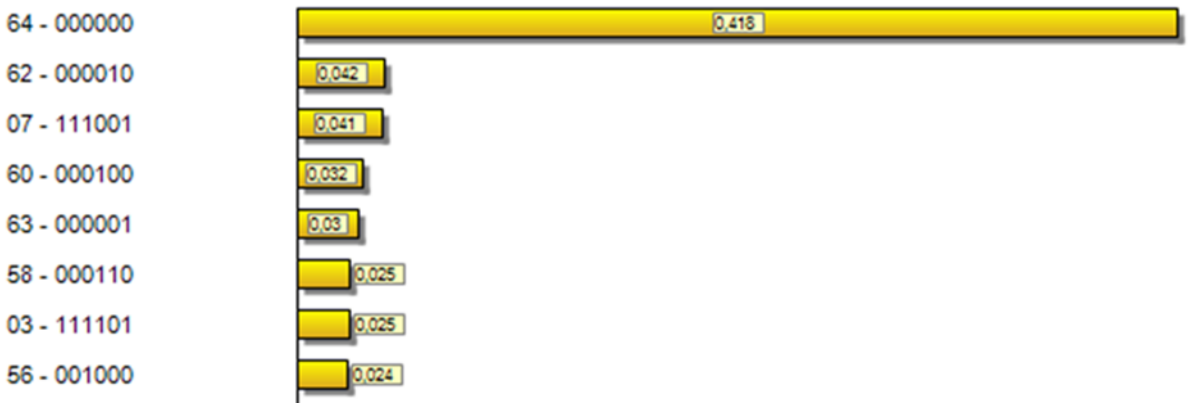

Figure 2-5. Histogram of probability scenarios (all experts)

The four scenarios with higher probability were:

1. Scenario 000000 - without any intervention, probability 0,418
2. Scenario 000010 – corresponds to the hypothesis 5: WildAnimal - Other restoration - area for animal wildlife and wild-groving plants (WildAnimal Scenario), probability 0,042
3. Scenario 111001 – the combination of hypotheses: 1. Buildings - Other restoration - housebuild, industry and market areas; 2. HorseTrail - Other restoration - horse trails around riding hall for active recreation; 3. Pastures - Agricultural restoration - flowery meadow and pastures; 6. ForestPark - Forest park, city wildness, workout areas; probability 0,041
4. Scenario 000100 - ForestPark - Forest park, city wildness, workout areas (Forestpark scenario), probability 0,032

According to the Smic Prob-Expert tool, scenario 000000 has the highest probability, ie leaving the territory without any intervention. Scenarios 000010 (WildAnimal) and 111001 (combination of Building, HorseTrail, Pastures, ForestPark) show a very similar probability. However, WildAnimal scenario is logically closer to a non-intervention scenario, and therefore these two scenarios have been merged into one. Working title of this new summary scenario is Recreation. Within Recreation scenario, significant interventions in the territory of Ema - Terezie Mine dump complex are not expected, minor changes will prevail (planting and management of vegetation, installation of outdoor furniture, etc.), which lead to the ecological and recreational use of the dump complex.

The Smic Prob-Expert tool also allows tracing the scenarios preferred by the experts and converging positions between experts. The closer an expert is to a scenario, the most probable is its realisation. Equally, proximity between experts is used to identify their converging positions concerning the realisation probability of scenarios in jeopardy. Factorial Analysis (FA) is used, calculated from median probability vectors of scenarios corresponding to different experts and groups.

Figure 2-6 presents the closeness map between experts and scenarios. As it is shown, VŠB – TU Ostrava experts („Public „), professional experts - DIAMO, Slezská Ostrava municipality and NGO - Czech Union of of Nature Conservationists („Municipal“) are closer to the 000000 Scenario „without any interventions“, and 000100 Scenario (ForestPark), while Asental Group (Owners) is more closed to the 000010 Scenario (WildAnimal) and 111001 Scenario (Combination of hypotheses).

However, after merging the 000000 and 000010 Scenarios into the Recreation scenario, it can be said that all 3 groups of experts have a similar opinion on the potential

land use. It should be noted, that industry and building will remain in the original borders in most cases, only a small expansion is expected along these borders.

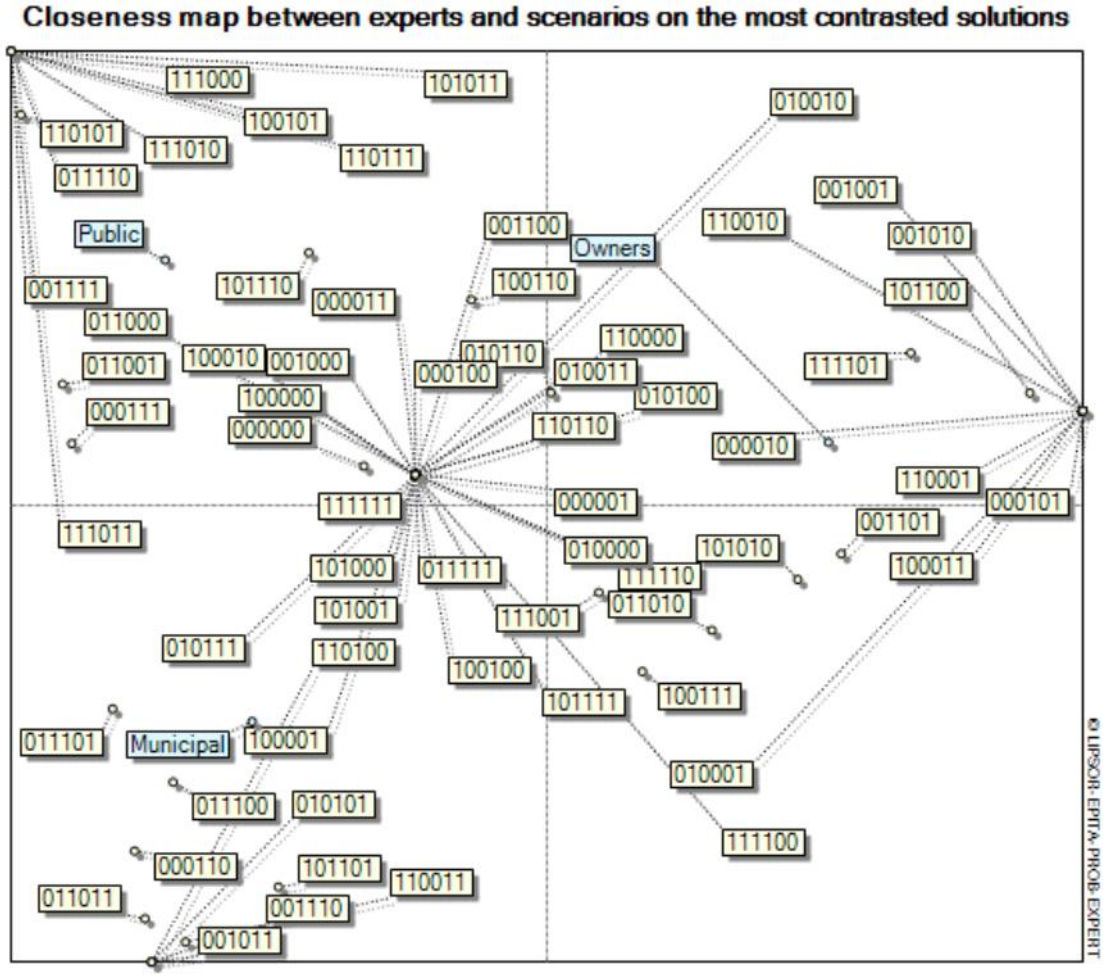

Figure 2-6. Closeness map between experts and scenarios

Figure 2-7 presents the histogram of influence sensitivity for all the experts. Sensitivity analysis estimates the probability change DPj of event j due to a probability change DPi of event i. Results are presented in the form of an elasticity matrix. Sensitivity analysis suggests which hypotheses to keep and which to discard to push the system in the direction wanted. The elasticities can be calculated via simulations, running the model of relations between probabilities a few times.

However, when there is a high number of experts, the impact of an event on another can be estimated by comparing displacements of P(i), P(i/ j), P(i/ -j) histograms.

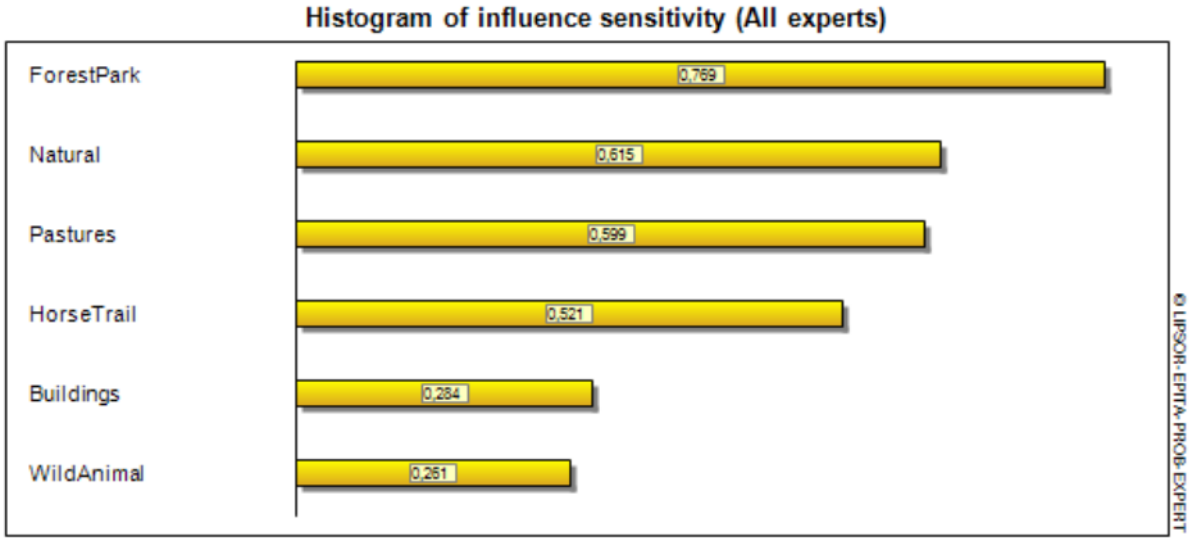

Figure 2-7. Histogram of influence sensitivity (all experts)

It has to be highlighted that the Smic Prob-Expert method transforms defined hypotheses probabilities by experts to coherent data, in other words respecting the basic probabilities' formulae. Net data computed by the software will hence replace the raw data provided by experts. An example of this is shown in Figure 2-8, which presents the conditional probability distribution realisation of Building Scenario (housebuild, industry and market areas) if Natural Scenario (natural and controlled succession) is realised for all groups of expert.

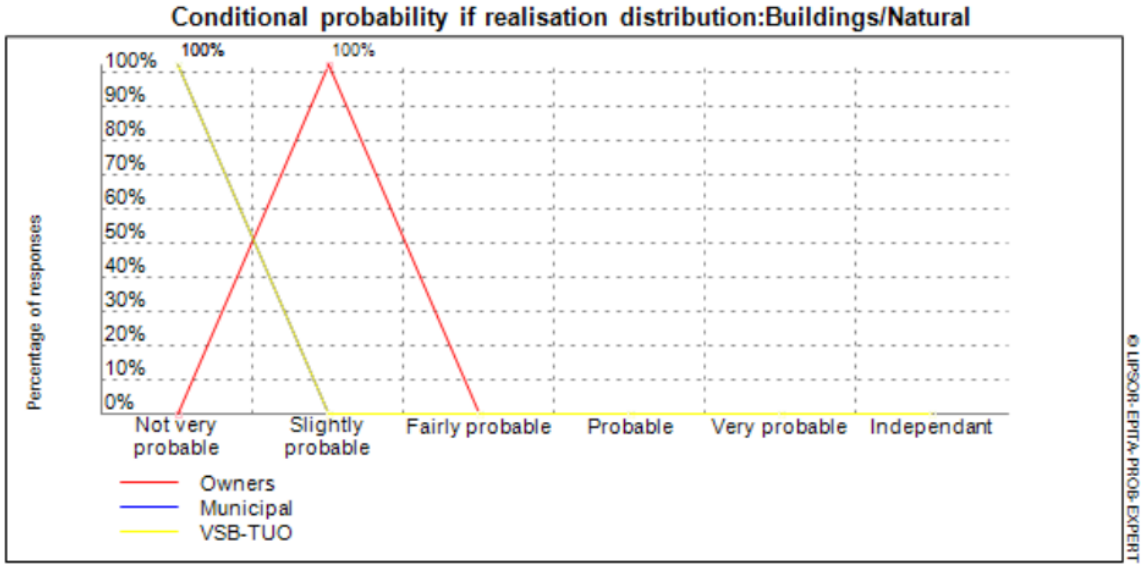

Figure 2-8. Conditional probability if realisation distribution: Buildings/Natural

3 The narrative for Ema – Terezie Mine dump complex scenarios

Next, and according to Larondelle & Haase (2021), a narrative for each selected scenario will be developed, including an overall vision for the new post-mining region and some clear targets.

Ema - Terezie - Bezruč Mine Dump complex is an old, partially reclaimed, thermally active area with the occurrence of protected species of organisms, it is also a very popular tourist destination. The Trojice valley, which is connected to this heap, has the character of an "urban wilderness", but is affected by extensive contamination from the former operation of the Trojice coke plant. Due to the nature of the pollution, which is proven exclusively in the unsaturated zone, no radical decontamination of the area is currently expected. From the point of view of these environmental characteristics and limitations, these scenarios can be predicted in the area (See Table 3-1).

Table 3-1. Narrative for the different scenarios of Ema – Terezie Mine Dump complex

Foreseen projects	Current state or foreseen projects
Scenario I (Recreation)	Scenario I is created by merging WildAnimal and "without any interventions" scenarios, which assumed only slight interventions in the area with a preference for extensive use. The mine dump complex is located almost in the center of the city of Ostrava, so it has significant potential for recreation and leisure – time activities. Except these recreational activities, also support of ecological functions is suitable and desirable for use in the area (establishment and management of flower meadows, support of entomofauna, etc.). Part of Ema – Terezie area is characterized by non-interventional urban wilderness by a Broad-leaved forest similar to the ones already present in the region: mainly *Betula pendula, Quercus robur, Sorbus aucuparia, Acer platanoides, Acer pseudoplatanus* and *Carpinus betulus* in terms of predominant ecological function. Nevertheless, this can be considered a mixed scenario of a Broad-leaved forest and a physical recreation area. People will be able to walk and undertake nature observation around the area, although without developing specific infrastructure for physical recreation.

Scenario II (Combination of hypoteheses)	Scenario II is a combination of the "Building", "HorseTrails", "Pastures" and "ForestPark" hypotheses. It assumes ecological, hippo - tourist and partly agricultural use of the area, especially with regard to horse breeding and riding school, which currently exists here.
Scenario III (ForestPark)	Scenario III is characterized in terms of the predominant recreational function, when a forest park with equipment for outdoor sports and outdoor furniture is built on the territory of the mine dump complex. Support for ecological functions is not as important as in Scenario 1.

4 Change rules for CLC land use classes

Narratives were translated into change rules for CLC land use classes with the if-then-else mode, according to Larondelle & Haase (2021). These change rules procedures and conditions for the Figaredo Mine area are shown in Table 4-1.

Table 4-1. Change rules for CLC land use classes (areas in ha)

Lad use	CLC 2006	Scenario I	Scenario II	Scenario III
Dumpsites	62,91	0	0	0
Discontinuous urban fabric	0	0	6,49	0
Sport and leisure facilities	0	0	15,85	0
Pastures	0	0	0,67	0,67
Mixed forest	0	62,91	39,9	62,24

5 Scenario maps

Finally, to expand the GIS web interface with the different scenarios, they were mapped according to previous Deliverables. Figure 5-1 shows Ema – Terezie Mine dump complex current state before restoration. Figure 5-2, Figure 5-3 and Figure 5-4 present the three scenarios considered after restoration.

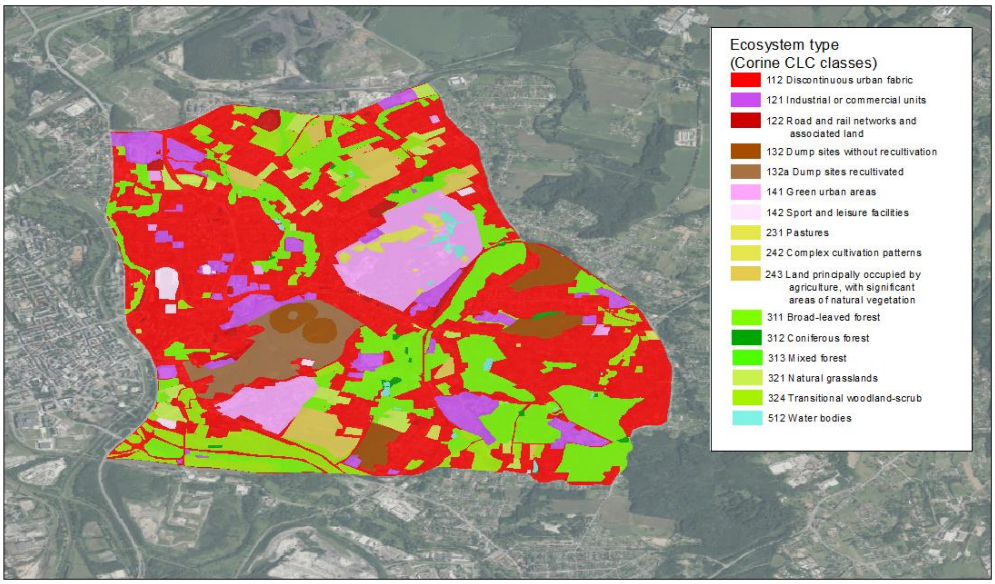

Figure 5-1. Ema – Terezie Mine dump complex - current state

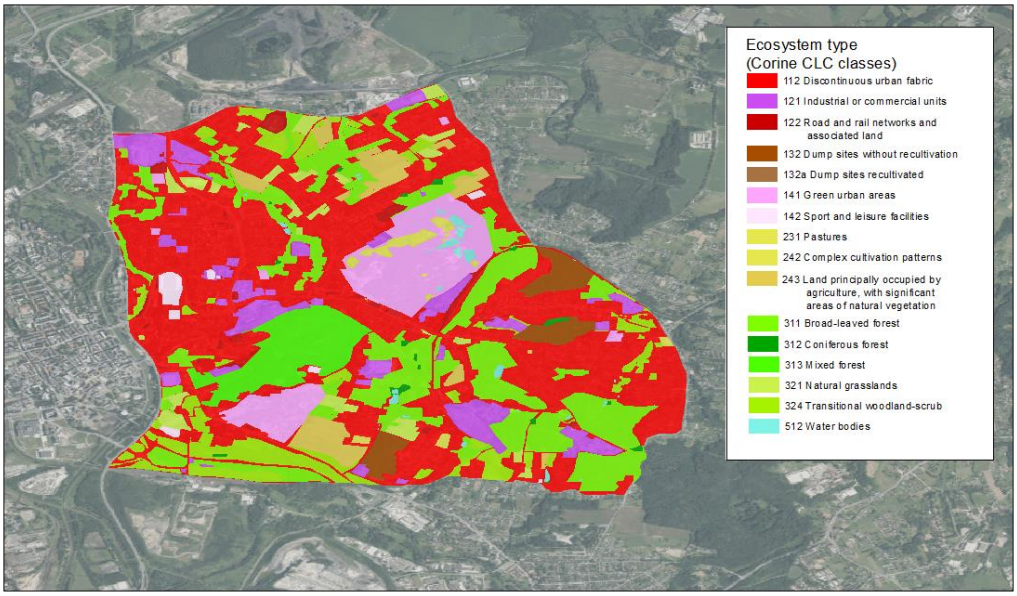

Figure 5-2. Scenario I: Recreation

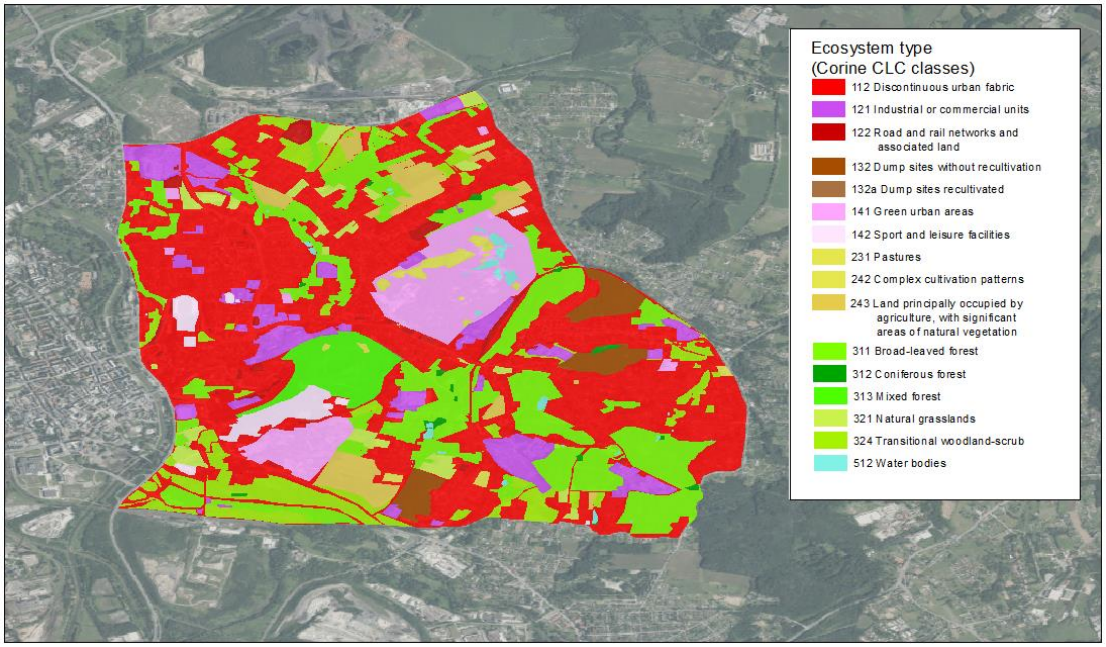

Figure 5-3. Scenario II: Combination of hypotheses

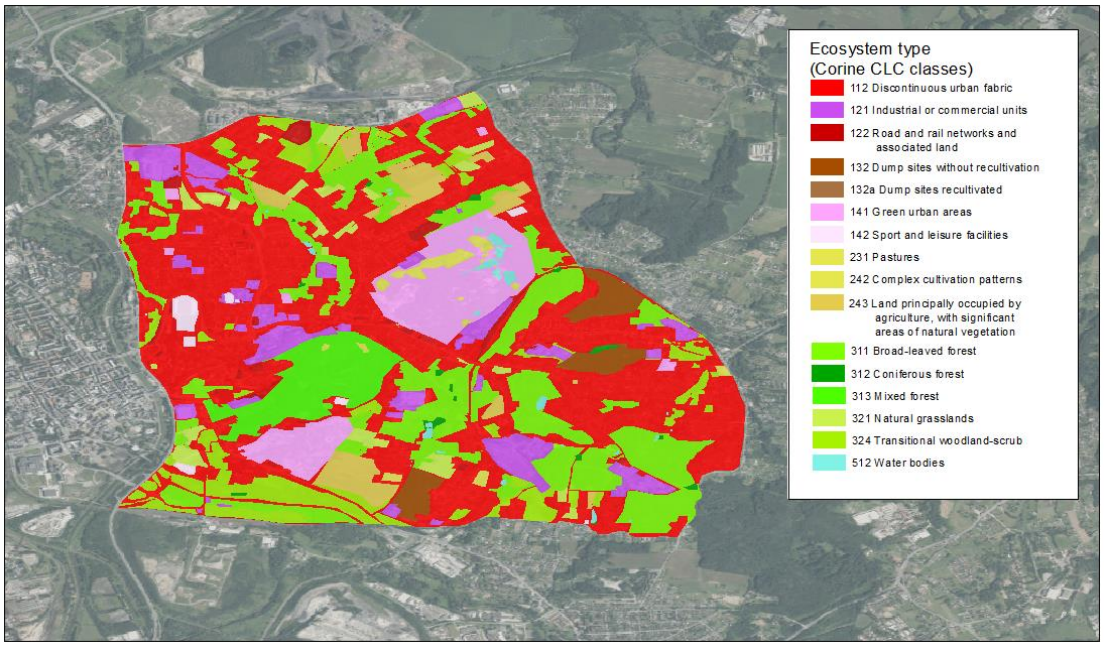

Figure 5-4. Scenario III: Forest Park

6 Conclusions & lessons learnt

To create suitable scenarios, VŠB - TU Ostrava prepared 8 alternatives for future planning and development of Ema - Terezie Mine dump complex (see Figure 6-1). Particular emphasis was given to consultation of alternatives and subsequent scenarios with stakeholders (representatives of municipality, representatives of mining industry, professional public, environmental NGOs and landowners) to guarantee the success of the whole process.

The following six alternatives were considered as the most usable by the VŠB – TU Ostrava, Slezská Ostrava municipality, DIAMO, state enterprise, Czech Union of Nature Conservationists and landowner Asental Group: 1. Other restoration - housebuild industry and market areas; 2. Other restoration - horse trails around riding hall for active recreation; 3. Agricultural restoration - flowery meadow and pastures; 4. Other restoration - natural and controlled succession, 5. Other restoration - area for animal wildlife; 6. Forest park, city wildness, workout areas.

After conditional and straightforward probabilities were introduced in the Smic Prob-Expert tool, it was possible to determine the probability of all the possible scenarios. The main problem here was that to instruct the non-scientific stakeholders. The solution was to support them within all the process.

The scenarios selected were Urban wildness (non-intervention); Wild Animal; and Combination of Building, Horse Trail, Pastures and Forestpark. Wild Animal and the Combination of Building, Horse Trail, Pastures and Forestpark show a very similar probability. However, WildAnimal scenario is logically closer to a non-intervention scenario, and therefore these two scenarios have been merged into one. Working title of this new summary scenario is Recreation. Within Recreation scenario, significant interventions in the territory of Ema - Terezie Mine dump complex are not expected, minor changes will prevail (planting and management of vegetation, installation of outdoor furniture, etc.), which lead to the ecological and recreational use of the dump complex.

7 Glossary

CICES - Common International Classification of Ecosystem Services

CIF - Common Implementation Framework

CLC - CORINE Land Cover

CORINE - Coordination of information on the environment

DIAMO - DIAMO, state enterprise

EEA - European Environment Agency

ES - Ecosystem Service

GIS - Geographic information system

MA - Millennium Ecosystem Assessment

MAES - Mapping and Assessment of Ecosystem Services

MFA - Morphological Field Analysis

SEEA - System of Environmental and Economic Accounting

SMIC - Smic-Prob Expert

UNSD - United Nations Statistical Division

VSB – TU Ostrava - VSB – Technical university of Ostrava

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9 Glossary

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CLC - CORINE Land Cover

CORINE - Coordination of information on the environment

EEA - European Environment Agency

ES - Ecosystem Service

GIS - Geographic information system

HUNOSA - Hulleras del Norte S.A.

MA - Millennium Ecosystem Assessment

MAES - Mapping and Assessment of Ecosystem Services

MFA - Morphological Field Analysis

SEEA - System of Environmental and Economic Accounting

SMIC - Smic-Prob Expert

UNIOVI - University of Oviedo

UNSD - United Nations Statistical Division