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

847205-RECOVERY-RFCS-2018

Deliverable 3.7

Assessment of scenarios for Chabařovice and Most-Ležáky Mine

European Commission

Research Fund for Coal & Steel

Author

Bc. Vít Kopecký, PKÚ

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	D3.7 Assessment of scenarios for Chabařovice and Most-Ležáky Mine
Keywords	Assessment, scenarios, planning, Chabařovice, Most-Ležáky Mine

Content

List of Figures

List of Tables

Executive Summary

Within this Deliverable, the assessment of future scenarios for Chabařovice and Most-Ležáky Mine.

In order to select the scenarios that should be considered for the Chabařovice and Most-Ležáky Mine case study area, stakeholder consultation was used as a reference, together with the different types of land rehabilitation and ecosystem restoration alternative actions that were proposed within the RECOVERY Project in order to generate different scenarios in mining-affected areas. For Lake Milada an interview was conducted with the mayor of Chabařovice, who is one of the main actors from the surrounding authorities in the revitalization of Lake Milada.

The Smic Prob-Expert tool was used to facilitate the scenario selection. The Smic Prob-Expert tool is a cross-impact probability method that aims to define simple and conditional probabilities of hypotheses and events and the probabilities of combinations of the latter, taking into account interactions between events or hypotheses. The goal of this method is to tease out the most plausible scenarios for decision-makers and examine combinations of hypotheses that one would have initially excluded.

Once the scenarios to be analysed were selected, a narrative for each of them was developed, including an overall vision for the new post-mining region.

The translation of the narratives followed it into change rules, procedures and conditions for CLC land use classes using the if-then-else mode.

Finally, to expand the GIS web interface with the different scenarios, they were mapped according to previous Deliverables.

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. Recolonisation of the site by local vegetation.
2. Commercial forestry plantations.
3. Secondary forests using local plant species.
4. Development for agriculture: arable land and pastures.
5. Leisure and recreational purposes: museums and recreation areas.
6. Areas for physical recreation.
7. Space for wildlife and nature conservation.
8. Development of artificial water bodies, e.g., lakes, reservoirs, streams, etc.
9. Renewable energy generation: photovoltaic and wind power.
10. Industrial areas and business facilities
11. Residential areas, 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.

Although one of the objectives of Work Package Nº 3 was to map and quantify the new ecosystem services provision of each generated scenario in order to enable the analysis of changes in services delivery which are required for quantifying trade-offs among them, this work can not be done before the selection of the suitable indicators that will allow a proper quantification of every ecosystem service involved in the coal-mining affected areas. Thus, this work will be postponed to the following work packages.

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 3.7 will undergo the assessment of scenarios for Chabařovice and Most-Ležáky Mine, property of ASENTAL Group in Czech Republic.

2 Assessment of scenarios for Chabařovice Mine

Special emphasis was given to consultation of scenarios with stakeholders (local authorities, neighbourhood associations, coal mining industry, trade unions and environmental NGOs), in order to guarantee the success of the whole process. Each partner was responsible for the involvement of stakeholders from his case-study areas.

For Chabařovice Mine, respectively for Lake Milada an interview was conducted with the mayor of Chabařovice, who is one of the main actors from the surrounding authorities in the revitalization of Lake Milada.

Among the different actions, the following six alternatives were considered as the most feasible, taking into consideration Chabařovice mine area features:

1. Physical recreation and freetime activity
2. Biking trails
3. Leisure areas
4. Urban areas
5. Grassland
6. Transitional woodland shrub

These alternatives were introduced in the Smic Prob-Expert tool as the hypothesis to be used for developing the scenario assessment (Figure 2-1).

Hypothesis list

#	Long label	Short label	Description
1	Physical recreation and freetime activit	recreation	
2	biking trails	trails	
3	leisure areas	leisure	
4	urban areas	urban	
5	grassland	grassland	
6	transitional woodland shrub	shrub	

Figure 2-1. 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”. With this purpose, two group of experts were formed: Chabařovice town (Chaba) and Palivový kombinát Ústí, s. p. (PKU). In the second place, the expert groups defined the “conditional probabilities of hypotheses, if other hypotheses realised”. In the third place, the “conditional probabilities of hypotheses, if other hypotheses non-realisation” were defined.

After simple and conditional probabilities were introduce 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 as a whole. This is 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. The raw data provided by experts will hence be replaced by net data computed by the software.

Figure 2-2 presents the histogram of probability scenarios according to all the experts.

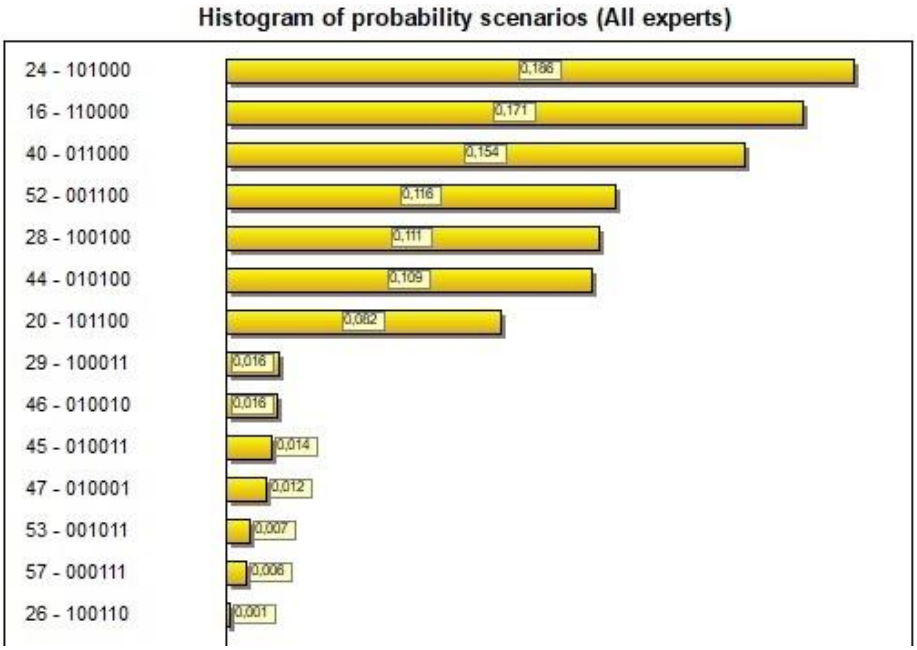

Figure 2-2. Histogram of probability scenarios (all experts)

The four scenarios with higher probability were:

1. **Scenario 101000** that corresponds to the hypothesis 1 and 3 with a probability of 0.186. This scenario will be called Recreation.
2. **Scenario 110000** that corresponds to the hypothesis 1 and 2 with a probability of 0.171. This scenario will be called Sport.
3. **Scenario 011000** that corresponds to the hypothesis 2 and 3 with a probability of 0.154.
4. **Scenario 001100** that corresponds to the hypothesis 3 and 4 with a probability of 0.116.

The top 2 scenarios have similar probabilities. Even the third scenario is followed by a small margin. If we look at scenarios from wider perspective, the 7 most probable scenarios are followed very closely, which are mixture of hypothesis 1 – 4. It is showing that experts are preferring active social revitalization in comparison to simple green reclamation. This is mainly because remediation and reclamation actions are mostly complete on the Lake Milada and the upcoming process is revitalization with focus on tourism but with natural aspects.

The Smic Prob-Expert tool also allows to trace the scenarios preferred by the experts, as well as 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 with respect to realisation probability of scenarios in jeopardy. Factorial Analysis (FA) is used. This is calculated from median probability vectors of scenarios corresponding to different experts and groups.

Figure 2-3 presents the closeness map between experts and scenarios. As it is shown, PKU experts and Chaba experts are not favouring any of the scenarios desperately. Chaba experts are slightly more into Urban areas and natural hypotheses combination in comparison to PKU experts who are more into Recreation and natural hypotheses combination.

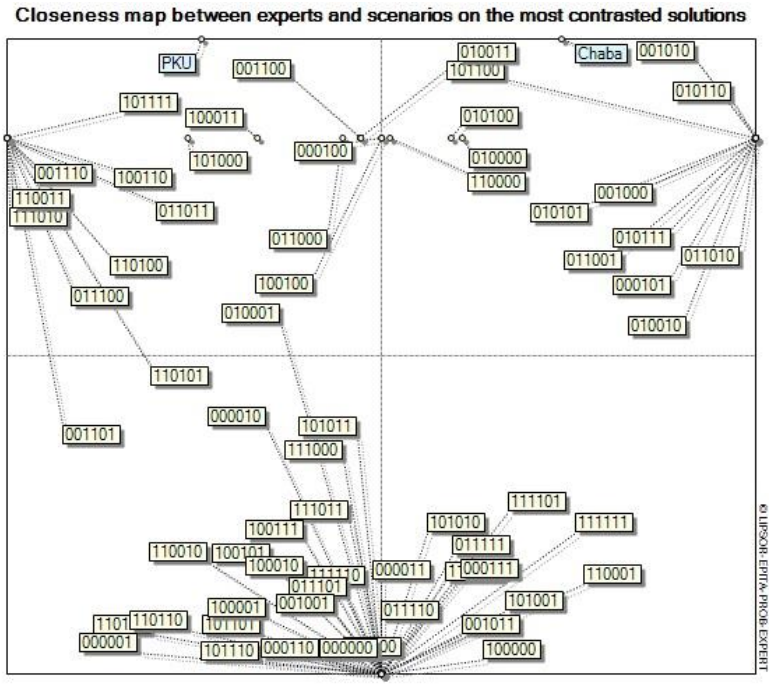

Figure 2-3. Closeness map between experts and scenarios

Figure 2-4presents the histogram of influence sensitivity for all the experts. Sensitivity analysis estimates the probability change DP_j of event *j* due to a probability change DP_i of event *i*. Results are presented in the form of an elasticity matrix. Sensitivity analysis suggests which hypotheses too 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.

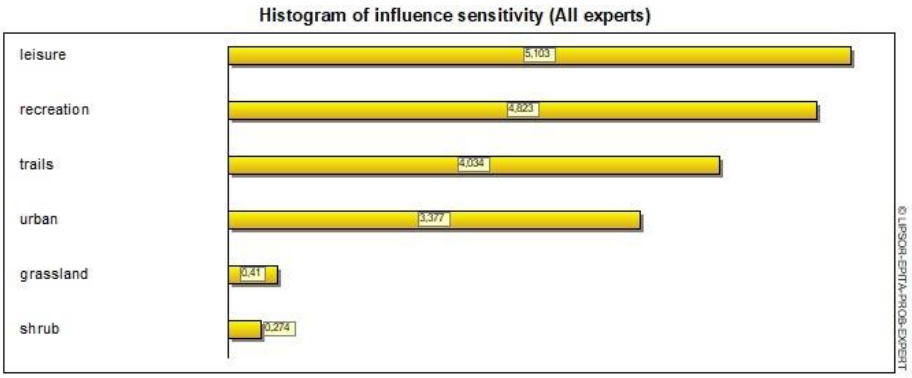

Figure 2-4. Histogram of influence sensitivity (all experts)

Finally, it must 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. The raw data provided by experts will hence be replaced by net data computed by the software. An example of this is shown in Figure 2-5, that presents the conditional probability distribution of the Physical recreation and free time activity if non-realisation of the Urban areas.

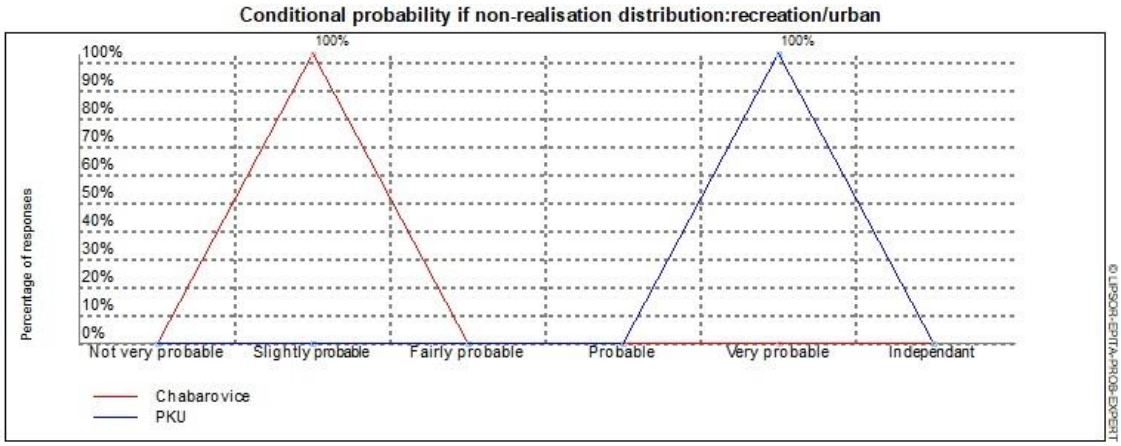

Figure 2-5. Conditional probability if non-realisation distribution: Recreation/Urban

Foreseen projects	Current state or foreseen projects
Scenario I (Recreation)	Scenario I is created by merging Physical recreation, freetime activity and leisure areas. At the moment on Chabařovice mine reclamation and remediation process is completed. The revitalization process is ongoing and there are many activities and all of stakeholders agreed on focus on tourism. There are even regional studies in creation. Main activities in this scenario are to create complex facilities for especially for water sports.
Scenario II (Combination of scenarios)	Scenario II is a combination of the Physical recreation, freetime activity, leisure areas and biking trails. This scenario is very similar to the scenario the scenario I with addition of biking trails because scenario III includes also Physical recreation and freetime activity.
Scenario III (Sport)	Scenario III is created by merging Physical recreation and freetime and biking trails. Biking trails are on the rise in the area. And with the steeper slopes on south, it is ideal place.

Table 2-1 Narrative for the different scenarios of Chabařovice mine

3 Scenario maps

Finally, to expand the GIS web interface with the different scenarios, they were mapped according to previous Deliverables. Figure 3-1 shows Chabařovice mine in the current state before restoration. Figure 3-2, Figure 3-3 and Figure 3-4 present the three scenarios considered after restoration.

Figure 3-1. Chabařovice mine - current state

Figure 3-2. Scenario I: Recreation

Figure 3-3. Scenario II: Combination of scenarios

Figure 3-4. Scenario III: Sport

4 Assessment of scenarios for Most-Ležáky Mine

Special emphasis was given to consultation of scenarios with stakeholders (local authorities, neighbourhood associations, coal mining industry, trade unions and environmental NGOs), 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, the following six alternatives were considered as the most feasible, taking into consideration Most-Ležáky Mine area features:

1. Physical recreation and freetime activity
2. Urban areas
3. Broad-leaved plantation
4. Transitional woodland shrub
5. Grassland
6. Biking and hiking trails

These alternatives were introduced in the Smic Prob-Expert tool as the hypothesis to be used for developing the scenario assessment (Figure 4-1).

Hypothesis list

#	Long label	Short label	Description
1	Physical recreation and freetime activit	recreation	
2	urban area	urban	
3	broad-leaved plantation	trees	
4	transitional woodland shrub	shrubs	
5	grassland	grassland	
6	biking and hiking trails	trails	

Figure 4-1. 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”. With this purpose, two group of experts were formed: Palivový kombinát Ústí, s. p. (PKU) and Statutární mesto Most (Most). In the second place, the expert groups defined the “conditional probabilities of hypotheses, if other hypotheses realised”. In the third place, the “conditional probabilities of hypotheses, if other hypotheses non-realisation” were defined.

After simple and conditional probabilities were introduce 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. This is 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. The raw data provided by experts will hence be replaced by net data computed by the software.

Figure 4-2 presents the histogram of probability scenarios according to all the experts.

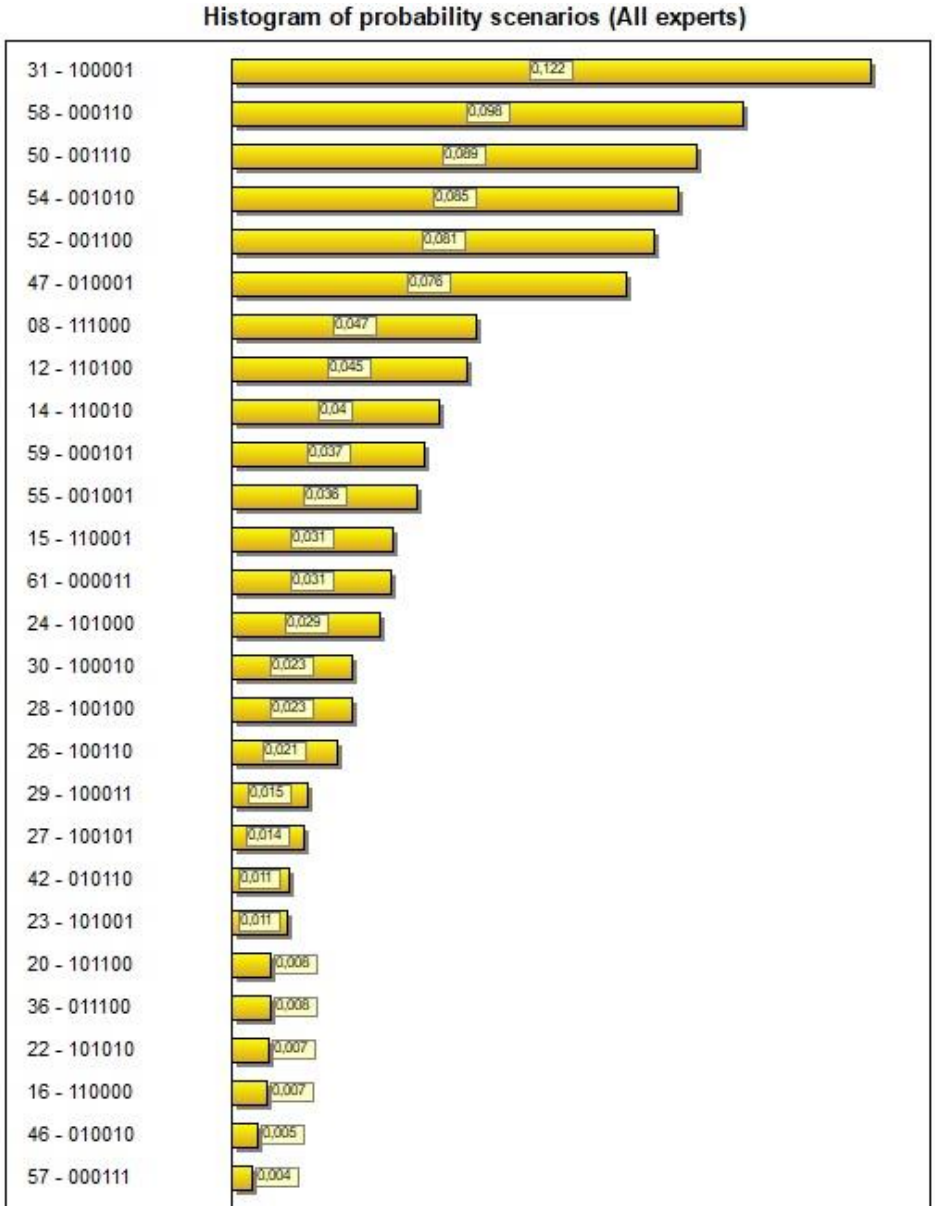

Figure 4-2. Histogram of probability scenarios (all experts)

The four scenarios with higher probability were:

1. **Scenario 100001** that corresponds to the hypotheses 1 and 6 with a probability of 0.122. This scenario will be called Recreation.
2. **Scenario 000110** that corresponds to the hypotheses 4 and 5 with a probability of 0.096. This scenario will be Nature.
3. **Scenario 001110** that corresponds to the hypotheses 3, 4 and 5 with a probability of 0.089.
4. **Scenario 001010** that corresponds to the hypotheses 3 and 5 with a probability of 0.085.

Recreation scenario has greater probability difference from other scenarios. Nature scenario has similar probability to from 3rd to 5th highest probabilities. These are also focused on natural hypotheses.

The Smic Prob-Expert tool also allows to trace the scenarios preferred by the experts, as well as 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 with respect to realisation probability of scenarios in jeopardy. Factorial Analysis (FA) is used. This is calculated from median probability vectors of scenarios corresponding to different experts and groups.

Figure 4-3 presents the closeness map between experts and scenarios. As it is shown, Most experts are closer to Urban and Recreational scenarios. PKU apart from Recreational and Urban to the Nature scenarios.

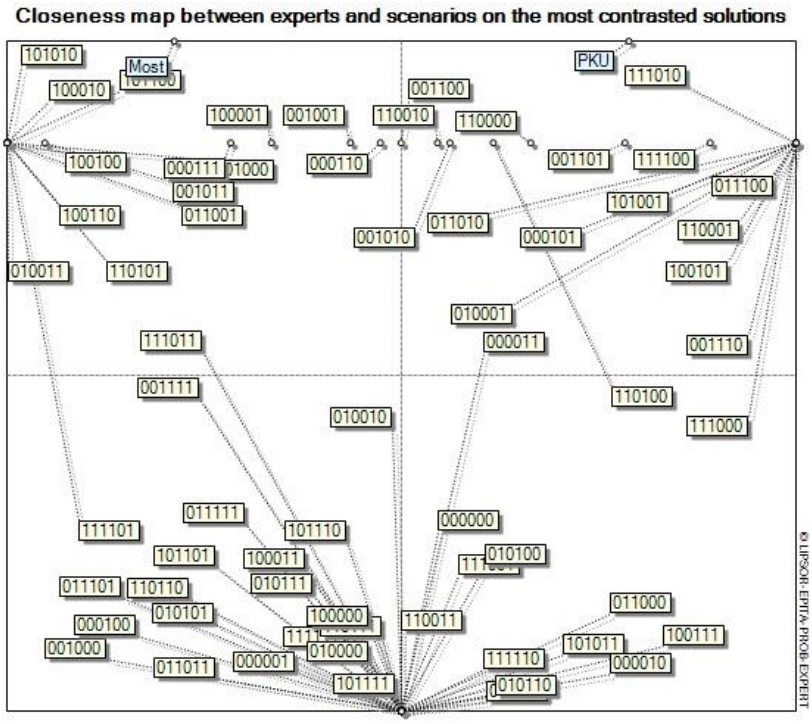

Figure 4-3. Closeness map between experts and scenarios

Figure 4-4 presents the histogram of influence sensitivity for all the experts. Sensitivity analysis estimates the probability change DP_j of event *j* due to a probability change DP_i of event *i*. Results are presented in the form of an elasticity matrix. Sensitivity analysis suggests which hypotheses too 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.

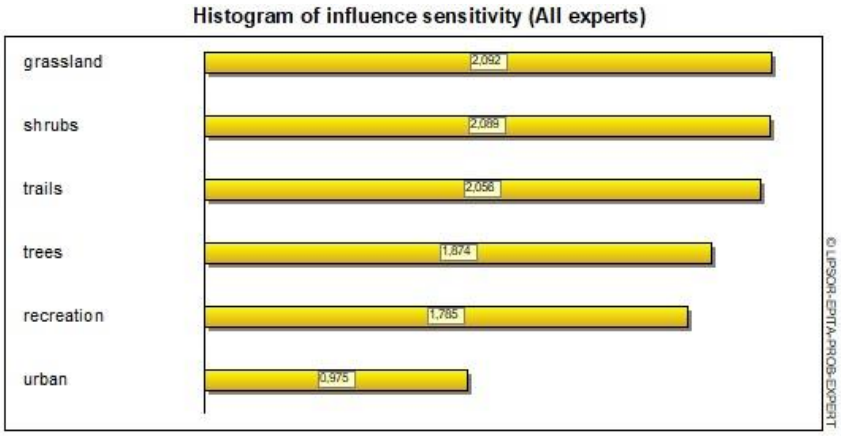

Figure 4-4. Histogram of influence sensitivity (all experts)

Finally, it must 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. The raw data provided by experts will hence be replaced by net data computed by the software. An example of this is shown in Figure 4-5, that presents the conditional probability distribution of Physical recreation and free time activity if non-realisation of the Urban area.

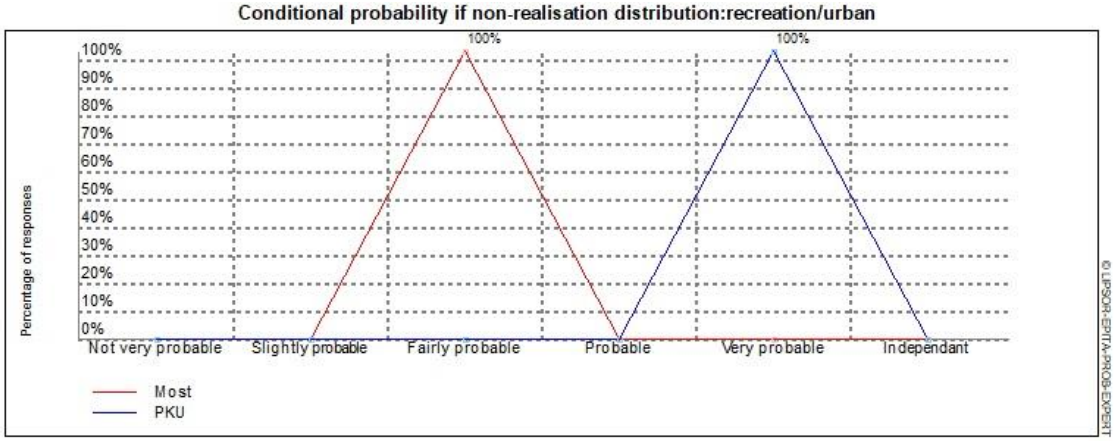

Figure 4-5. Conditional probability if non-realisation distribution: recreation/urban

Foreseen projects	Current state or foreseen projects
Scenario I (Recreation)	Scenario I is created by merging Physical recreation and freetime activity with biking and hiking trails. Physical recreation and freetime activity is under the process in the south area of the Most-Ležáky mine. There are plans to create facilities with focus on water sports supplemented with other summer activities.
Scenario II (Combination of scenarios)	Scenario II is a combination of the Physical recreation and freetime activity, biking and hiking trails, transitional woodland shrub, and natural grassland. This scenario is focused on recreation with respecting the nature aspect of the area.
Scenario III (Nature)	Scenario III is created by merging transitional woodland shrub and natural grassland. This scenario focuses on leaving the area to more natural development without major interventions in the landscape.

Table 4-1 Narrative for the different scenarios of Most- Ležáky mine

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 Most-Ležáky mine in the current state before restoration. Figure 5-2, Figure 5-3 and Figure 5-4 present the three scenarios considered after restoration.

Figure 5-1. Most-Ležáky mine - current state

Figure 5-2. Scenario I: Recreation

Figure 5-3. Scenario II: Combination of scenarios

Figure 5-4. Scenario III: Nature

6 Conclusions and lessons learned

For the purpose of assessment of scenarios for Chabařovice and Most-Ležáky Mine, in the first place a workshop for selecting the different types of land rehabilitation and ecosystem restoration actions that can be proposed to generate different scenarios in mining-affected areas was developed during the 6th Microsoft TEAMS meeting of the Recovery Project, that took place on May the 25th, 2021.

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

Among the different actions, the following six alternatives were considered as the most feasible, taking into consideration Chabařovice mine area features:

1. Physical recreation and free time activity
2. Biking trails
3. Leisure areas
4. Urban areas
5. Grassland
6. Transitional woodland shrub

Among the different actions, the following six alternatives were considered as the most feasible, taking into consideration Most-Ležáky Mine area features:

1. Physical recreation and free time activity
2. Urban areas
3. Broad-leaved plantation
4. Transitional woodland shrub
5. Grassland
6. Biking and hiking trails

These alternatives were introduced in the Smic Prob-Expert tool as the hypothesis to be used for developing the scenario assessment with the opinions of two groups of experts for each case study: PKU and Chaba for Chabařovice mine and PKU and Most for Most-Ležáky mine.

For Chabařovice mine higher probability scenarios were physical recreation and free time activity, biking trails, and leisure areas. For Most-Ležáky mine higher probability scenarios were physical recreation and free time activity, transitional woodland shrub, grassland and biking and hiking trails.

There is no wonder that both case studies scenarios are focused on recreation because these processes are ongoing and in the close area there are other mines closing in the nearest future. One difference between the case studies is that Most-Ležáky mine is slightly more focused on natural aspects. This is because reclamation in this area took place later than in Chabařovice mine, so the reclamation phase is not completely finished. There are plans to have Chabařovice mine and Most-Ležáky mine focused on recreation and tourism and the other on renewable energy not to cause excessive competition.

7 Glossary

CIF - Common Implementation Framework

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

SMIC - Smic-Prob Expert

UNIOVI - University of Oviedo

8 References

Altun, A. O., Yilmaz, I., & Yildirim, M. (2010). A short review on the surficial impacts of underground mining. *Scientific Research and Essays*, *5*(21), 3206–3212.

Börjeson, L., Höjer, M., Dreborg, K. H., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques: Towards a user's guide. *Futures*, *38*(7), 723–739. https://doi.org/10.1016/j.futures.2005.12.002

Fagiewicz, K. (2014). Spatial processes of landscape transformation in mining areas (Case study of opencast lignite mines in Morzysław, Niesłusz, Gosławice). *Polish Journal of Environmental Studies*, *23*(4), 1123–1136.

Godet, M. (2000). The Art of Scenarios and Strategic Planning: Tools and Pitfalls. *Technological Forecasting and Social Change*, *65*(1), 3–22. https://doi.org/10.1016/s0040-1625(99)00120-1

Larondelle, N., & Haase, D. (2012). Valuing post-mining landscapes using an ecosystem services approach - An example from Germany. *Ecological Indicators*, *18*, 567–574. https://doi.org/10.1016/j.ecolind.2012.01.008

Maes, J., Teller, A., Erhard, M., Liquete, C., Braat, L., Berry, P., Egoh, B., Puydarrieus, P., Fiorina, C., Santos, F., Paracchini, M. L., Keune, H., Wittmer, H., & Hauck, J. (2013). *Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020*. Publications Office of the European Union, Luxembourg. https://doi.org/10.2779/12398

Mancini, L., & Sala, S. (2018). Social impact assessment in the mining sector: Review and comparison of indicators frameworks. *Resources Policy*, *57*(April 2017), 98–111. https://doi.org/10.1016/j.resourpol.2018.02.002

Meng, L., Feng, Q. yan, Zhou, L., Lu, P., & Meng, Q. jun. (2009). Environmental cumulative effects of coal underground mining. *Procedia Earth and Planetary Science*, *1*(1), 1280–1284. https://doi.org/10.1016/j.proeps.2009.09.198

Millenium Ecosystem Assessment. (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC. https://doi.org/https://doi.org/10.5822/978-1-61091-484-0_1

Schwarz, N., Bauer, A., & Haase, D. (2011). Assessing climate impacts of planning policies-An estimation for the urban region of Leipzig (Germany). *Environmental Impact Assessment Review*, *31*(2), 97–111. https://doi.org/10.1016/j.eiar.2010.02.002

Verweij, P., Janssen, S., Braat, L., van Eupen, M., Pérez Soba, M., Winograd, M., de Winter, W., & Cormont, A. (2016). QUICKScan as a quick and participatory methodology for problem identification and scoping in policy processes. *Environmental Science and Policy*, *66*, 47–61. https://doi.org/10.1016/j.envsci.2016.07.010

Xiang, W. N., & Clarke, K. C. (2003). The use of scenarios in land-use planning. *Environment and Planning B: Planning and Design*, *30*(6), 885–909. https://doi.org/10.1068/b2945