Recovery

RFCS RESEARCH PROJECT

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

847205-RECOVERY-RFCS-2018

Deliverable 1.2

Comprehensive overview of the project: state of the art

European Commission

Research Fund for Coal & Steel

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1 Introduction

RECOVERY project focuses on land rehabilitation and ecological restoration of coal mining-affected areas, aiming to accelerate the recovery of degraded and transformed ecosystems to a good ecosystem status. It will assess the contribution of these ecosystems to human wellbeing by means of the 'ecosystem-services' concept, evaluating the consequences of alternative courses of action to ensure that their capacity to provide benefits to society is not diminished.

The objectives of RECOVERY are:

1. To give guidance for policy and decision-makers in order to select the land rehabilitation and ecological restoration actions, which deliver the greatest benefits relative to their costs, identifying optimal alternatives and devising suitable strategies.
2. To increase the impact of land rehabilitation and ecological restoration actions on both society and environment by demonstrating the opportunities that coal mining sites have to improve overall public welfare and giving information on the environmental and social cost-effectiveness of these actions.
3. To enhance simultaneously the delivery of EU policies by the coal mining industry: waste management policy (Directive 2006/21/EC), climate and energy policies (COM/2016/0479 final), and biodiversity policy (COM/2011/244).
4. To deliver 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.
5. To deliver, addressing specifically coal mining-affected areas: (a) detailed costs of alternative land rehabilitation and ecological restoration actions, as well as the benefits in the provision of ecosystem services; (b) a first set of suitable indicators for these ecosystem services; and (c) feasible valuation techniques and optimal discount rates.
6. To deliver and innovative framework for land rehabilitation and ecological restoration of coal mining-affected areas, conceived as "Best practice guidelines" aiming to accelerate the recovery of these degraded and transformed ecosystems to a good ecosystem status.
7. To develop artificial substitutes for soils suitable to several types of plant communities, addressing 'difficult terrains' in coal mining waste heaps.
8. To propose suitable land rehabilitation techniques that allow successful environmental and vegetal developments in coal mining waste heaps.
9. To illustrate the benefits of implementing the project results and communicate the findings to the coal mining community across Europe.

2 State of the art

2.1 Relevant ongoing and closed projects

2.1.1 Research Fund for Coal and Steel (RFCS) Programme

There are only three RFCS projects of major relevance to the Project:

2.1.1.1 RFCR-CT-2015-00004 MERIDA

Management of environmental risks during and after mine closure, MERIDA, was completed in 2019. The objective of MERIDA was to design and provide technical guidance on the implementation of the investigations that should be undertaken in order to develop a mine closure plan.

Its aim is to minimise the environmental risks during mine closure and the post-closure periods in accordance with the general principle that the mine must take responsibility and minimise all risks that can be foreseen. It provides a planning tool that allows the design of a step-wise approach to mine closure that can be progressively refined during the post-closure period and allows addressing all relevant environmental risks.

RECOVERY will fill the gap between MERIDA's mine closure plan and the mine site reclamation, closing the complete life cycle of coal mines in order to return these mine sites to society in a good ecosystem status and with an improved capacity to provide benefits.

2.1.1.2 RFC-PR-2012-12029 MANAGER

Management of mine water discharges to mitigate environmental risks for the post-mining period, MANAGER, was completed in 2016. MANAGER aimed to develop innovative water treatment technologies and approaches to manage mine water discharge as well as pilot implementation of the selected technologies.

The endpoints of the MANAGER project from the start of the research carried out in MERIDA on the modelling of environmental impacts and the assessment of risks to the environment.

One of the case-studies of RECOVERY is the waste heap of Janina Mine, property of Tauron Wydobycie S.A. (TWD), industrial partner of RECOVERY that operates it from the beginning of the twentieth century. In this waste heap, MANAGER underwent a pilot study.

2.1.1.3 TEXMIN-RFCS-2019

The impact of extreme weather events on mining operations, TEXMIN, will take place from 2019 till 2022. The main objective of TEXMIN project is to provide guidance to all stakeholders on gradual and sudden impacts on operating, closed and abandoned coal mines brought about by climate change and extreme weather events. RECOVERY will use strategies and monitoring solutions developed in TEXMIN on how to reduce the impact and vulnerability of sites to climate change. Also experience from the pilot tests planned within TEXMIN will used on the remedial measures for stabilisation of mine spoil dump in case of extreme weather events occurrence.

2.1.2 Horizon 2020 Programme

Within the H2020 Programme, all projects of major relevance for the proposal address specifically the enhancement of ecosystem services from a general point of view:

2.1.2.1 H2020-2015-641762 ECOPOTENTIAL

Improving future ecosystem benefits through earth observations, ECOPOTENTIAL, was completed in 2019. Its objective was to develop knowledge-based conservation, management and restoration policies in order to improve ecosystem benefits in face of increasing pressures that cause serious threat to ecosystems, leading to habitat degradation, increased risk of collapse and loss of ecosystem services.

2.1.2.2 H2020-2015-642007 ESMERALDA

Enhancing ecosystem services mapping for policy and decision making, ESMERALDA, was completed in 2018. Its objective was to deliver a flexible methodology to provide the building blocks for Pan-European mapping and assessment of ecosystem services, supporting the needs of assessments for planning, water, nature policy, etc.

2.1.2.3 H2020-2015-655497 NNL

An exploration into the feasibility of simultaneously achieving 'No Net Loss' of biodiversity and ecosystem services, in an uncertain and changing world, NNL, was completed in 2017. Its objective was to find an optimal balance between development and ecosystems conservation, as human activity causes an ongoing loss of ecosystem services.

2.1.2.4 H2020-2020-844761 CESMINE

The project analyses the preferences of social network users for post-mining sites and the real use of the sites by the residents and by external visitors in three European countries. This is framed by the real socio-economic conditions revealed directly in the mining regions. The project combines quantitative and qualitative methods, using novel techniques such as social networks analyses, public participation GIS, and spatially explicit indicators of cultural ecosystem services.

2.1.3 Framework Programmes

Something similar happens with the projects developed under different Framework Programmes. Only quite old project (ENVIMAN) addresses aspects directly related with land rehabilitation in mining, but focusing only on the remediation of waste dumps:

2.1.3.1 FP7-ENV-2012-308428 OPENNESS

Operationalization of natural capital and ecosystem services: from concepts to real-world applications, OPENNESS, was completed in 2017.

It translated the concepts of natural capital and ecosystem services into operational frameworks that provide tested and practical solutions for integrating them into land, water and urban management, and decision-making.

2.1.3.2 FP7-ENV-2012-308393 OPERAS

Operational potential of ecosystem research applications, OPERAS, was completed in 2017. The project aimed to improve understanding of how applying the ecosystem services concept in managing ecosystems contributes to human well-being in different social-ecological systems.

2.1.3.3 FP7-PEOPLE-2010-IEF-273547 TRUEVALUE

Valuing ecosystem services, TRUEVALUE, was completed in 2013. Its relevant results were the determination of the values that European citizens place on ecosystem services like biodiversity and recreational use. Achieving an appropriate balance between such conflicting aims will depend partly on which services are deemed most important by the public.

2.1.3.4 FP5-ICA2-CT-10010 ENVIMAN

Environmental management of hazardous mining wastes and effluents, ENVIMAN, was completed in 2003. Its relevant results were: a detailed methodology for the

characterization of hazardous solid wastes and effluents, an innovative risk assessment methodology and techniques for the remediation of waste dumps and groundwater, as well as the development of an integrated waste management scheme.

2.1.4 LIFE Programme

LIFE TECMINE, to be completed in 2021, has the general objective of improving mine restoration in forest areas by testing new restoration techniques that deal with environmental and social issues not fully addressed by traditional techniques.

It aims to test and evaluate the feasibility and suitability of different restoration practices in mining areas of the Mediterranean, from the perspective of environmental, technical and social sustainability.

2.1.5 Other Programmes

Finally, within the ESCS Programme, the COALRES project investigating the impact of coal mines on the noise environment (completed in 1998), and within the Brite-EuRam Programme, the ROMBUSS project referring to rehabilitation and revegetation of waste-dumps by the use of industrial and tic sludges from waste-water puri plants; and H2OSENS project referring to development and implementation of water quality sensor systems for mines and landfill sites (both completed in 2000), could be of some relevance for RECOVERY, but their outcomes were achieved more than 20 years ago, that is why they were not considered.

2.2 International literature

2.2.1 Ecological restoration of coal mining-affected areas and ecosystem services

There are very few papers directly related with the ecological restoration of coal mining-affected areas and ecosystem services:

1. Feng, L.; Xusheng, L.; Dan Z.; Beibei, W.; Jiasheng, J. & Dan, H. (2011). Evaluating and modeling ecosystem service loss of coal mining: A case study of Mentougou district of Beijing, China. Ecological Complexity 8 (2011): 139-143.
2. Goldan, T.; Moraru, R.; Danciu, C. et al. (2012). Landscape restoration of areas affected by coal processing activities in western Jiu Valley, Romania. 12th International Multidisciplinary Scientific Geoconf. I: 639-643.
3. Larondelle, N. & Haase, D. (2012). Valuing post-mining landscapes using an ecosystem services approach - an example from Germany. Ecological Indicators 18: 567-574.

4. Pueffel, C., Haase, D., & Priess, J. A. (2018). Mapping ecosystem services on brownfields in Leipzig, Germany. Ecosystem Services, 30, 73–85.
5. Vuppaladadiyam, S., Baig, Z., Soomro, A., & Vuppaladadiyam, A. (2019). Characterisation of overburden waste and industrial waste products for coal mine rehabilitation. International Journal of Mining, Reclamation and Environment, 33:8, 517-526.
6. Sun, J., Yuan, X., Liu, H., Liu, G., & Zhang, G. (2019). Emergy evaluation of a swamp dike-pond complex: A new ecological restoration mode of coal-mining subsidence areas in China. Ecological Indicators, 107, 105660.
7. Zhang, M., Wang, J., & Feng, Y. (2019). Temporal and spatial change of land use in a large-scale opencast coal mine area: A complex network approach. Land Use Policy, 86, 375–386.
8. Zhenqi, H.; Yanhua, F.; Xiao, W. et al. (2015). Ecological restoration plan for abandoned underground coal mine site in Eastern China. International Journal of Mining Reclamation and Environment 29 (4): 316-330.

2.2.2 Waste heaps restoration in coal mines

Most of the literature related with coal mines deals with waste heaps restoration:

1. Barliza, J. C., Rodríguez, O. B., León Peláez, J. D., & Chávez, L. F. (2019). Planted forests for open coal mine spoils rehabilitation in Colombian drylands: Contributions of fine litterfall through an age chronosequence. Ecological Engineering, 138, 180–187.
2. Ciarkowska, K.; Gargiulo, L. & Mele, G. (2016). Natural restoration of soils on mine heaps with similar technogenic parent material: a case study of long-term soil evolution in Silesian-Krakow upland Poland. Geoderma, 261: 141-150.
3. Domínguez-Haydar, Y., Velásquez, E., Carmona, J., Lavelle, P., Chavez, L. F., & Jiménez, J. J. (2019). Evaluation of reclamation success in an open-pit coal mine using integrated soil physical, chemical and biological quality indicators. Ecological Indicators, 103, 182–193.
4. Hao, G.; Yun, F.; Fangfang, L. et al. (2016). Soil diagnosis and land suitability assessment for vegetation restoration on coal waste piles in Liupanshui, Guizhou, China. International Journal of Mining Reclamation and Environment 30 (3): 209-216.
5. Piekarska-Stachowiak, A.; Szary, M.; Ziemer, B.; et al. (2014). An application of the plant functional group concept to restoration practice on coal mine spoil heaps. Ecological Research 29 (5): 843-853.
6. Srivastava, N.K.; Ram, L.C.; Masto, R.E. (2014). Reclamation of overburden and lowland in coal mining area with fly ash and selective plantation: A sustainable ecological approach. Ecological Engineering 71 (2014): 479-489.

7. Tichanek, F. & Tichanek, R. (2014). Contribution to the solution of thermally active reclamation of coal wasteheaps. Geoconference on Science and Technologies in Geology, Exploration and Mining III: 777-791.
8. Zasterova, P.; Marschalko, M. ; Niemiec, D. et al. (2015). Analysis of possibilities of reclamation waste dumps after coal mining. Procedia Earth and Planetary Science 15: 656-662.

2.2.3 Ecological restoration and ecosystem services in mining

When the focus is open to mining in general, the amount of papers related with ecological restoration and ecosystem services, increases exponentially:

1. Carabassa, V., Ortiz, O., & Alcañiz, J. M. (2019). RESTOQUARRY: Indicators for self-evaluation of ecological restoration in open-pit mines. Ecological Indicators, 102, 437–445.
2. Cooke, J. A. & Johnson, M. S. (2002). Ecological restoration of land with particular reference to the mining of metals and industrial minerals: A review of theory and practice. Environmental Reviews, 10(1): 41-71.
3. Dallaire, K., & Skousen, J. (2019). Early tree growth in reclaimed mine soils in Appalachia USA. Forests, 10(7), 1–13.
4. Doley, D., & Audet, P. (2013). Adopting novel ecosystems as suitable rehabilitation alternatives for former mine sites. Ecological Processes, 2(1): 22-35.
5. Evans, D.M. et al. (2013). Reforestation practice for enhancement of ecosystem services on a compacted surface mine: Path toward ecosystem recovery. Ecological Engineering 51: 16-23.
6. Lorite, J. , Agea, D. , García-Robles, H. , Cañadas, E. M., Rams, S. and Sánchez-Castillo, P. (2019). Plant recovery techniques do not ensure biological soil-crust recovery after gypsum quarrying: a call for active restoration. Restor Ecol. Nov. 2019.
7. Morel, J.L.; Chenu, C. & Lorenz, K. (2015). Ecosystem services provided by soils of urban, industrial, traffic, mining, and military areas. Journal of Soils and Sediments 15 (8): 1659-1666.
8. Navarro-Cano, J. A., Goberna, M., & Verdú, M. (2019). Using plant functional distances to select species for restoration of mining sites. Journal of Applied Ecology, 56(10), 2353–2362.
9. Park, J.H.; Edraki, M.; Mulligan, D. & Jang, H.S. (2014). The application of coal combustion by-products in mine site rehabilitation. Journal of Cleaner Production 84 (2014): 761-772.
10. Wang, J.; Zhao, F.; Yang, J. & Li, X. (2017). Mining site reclamation planning based on land suitability analysis and ecosystem services evaluation: A case study in Liaoning Province, China. Sustainability, 9 (6): 890-904.

11. Wang, Z.; Lechner, A. M. & Baumgartl, T. (2017). Mapping cumulative impacts of mining on sediment retention ecosystem service in an Australian mining region. International Journal of Sustainable Development & World Ecology: 1-12.

2.2.4 Ecosystem restoration and ecosystem services

On the other hand, the existing literature on ecosystem restoration and ecosystem services, is really extensive:

1. De Groot, R. et al. (2012). Global estimates of the value of ecosystems and their services in monetary units. Ecosystem Services 1: 50-61.
2. De Groot, R. et al. (2013). Benefits on investing in ecosystem restoration. Conservation Biology 27 (6): 1286-1293.
3. Haase, D. et al. (2014). A quantitative review of urban ecosystem service assessments: concepts, models, and implementation. Ambio 43 (4): 413-433.
4. Jayachandran, S.; de Laat, J.; Lambin, E. F. et al. (2017). Cash for carbon: A randomized trial of payments for ecosystem services to reduce deforestation. Science 357 (6348): 267-273.
5. Kain, J. H.; Larondelle, N.; Haase, D.; & Kaczorowska, A. (2016). Exploring local consequences of two land-use alternatives for the supply of urban ecosystem services in Stockholm year 2050. Ecological Indicators, 70, 615–629.
6. Kremer, P., Larondelle, N., Zhang, Y., Pasles, E., & Haase, D. (2018). Within-class and neighborhood effects on the relationship between composite urban classes and surface temperature. Sustainability (Switzerland), 10(3).
7. Larondelle, N.; Frantzeskaki, N. & Haase, D. (2016). Mapping transition potential with stakeholder and policy-driven scenarios in Rotterdam City. Ecological Indicators 70: 630-643.
8. Liu, Y., Lü, Y., Fu, B., Harris, P., & Wu, L. (2019). Quantifying the spatio-temporal drivers of planned vegetation restoration on ecosystem services at a regional scale. Science of The Total Environment, 650, 1029–1040.
9. Mascarenhas, A.; Ramos, T. B.; Haase, D.; & Santos, R. (2016). Participatory selection of ecosystem services for spatial planning: Insights from the Lisbon Metropolitan Area, Portugal. Ecosystem Services, 18, 87–99.
10. Mavrommati, G.; Borsuk, M. & Howarth, R. (2017). A novel deliberative multicriteria evaluation approach to ecosystem service valuation. Ecology and Society 22 (2).
11. Potschin-Young, M.; Haines-Young, R.; Görg, C.; Heink, U.; Jax, K.; & Schleyer, C. (2018). Understanding the role of conceptual frameworks: Reading the ecosystem service cascade. Ecosystem Services, 29, 428–440.
12. Rey Benayas, J.M. et al. (2009). Enhancement of biodiversity and ecosystem services by ecological restoration: a meta-analysis. Science 325: 1121-1124.

13. Schmidt, K.; Walz, A.; Martín López, B. & Sachse, R. (2017). Testing socio-cultural valuation methods of ecosystem services to explain land use preferences. Ecosystem Services, 26: 270-288.
14. Srinivasan, S. (2015). Economic valuation and option-based payments for ecosystem services. Mitigation and Adaptation Strategies for Global Change 20 (7): 1055-1077.
15. Wegner, G.I. (2016). Payments for ecosystem services (PES): a flexible, participatory, and integrated approach for improved conservation and equity outcomes. Environment Development and Sustainability 18 (3): 617-644.
16. Wellmann, T., Haase, D., Knapp, S., Salbach, C., Selsam, P., & Lausch, A. (2018). Urban land use intensity assessment: The potential of spatio-temporal spectral traits with remote sensing. Ecological Indicators, 85(October 2017), 190–203.
17. Xu, C., Haase, D., & Pauleit, S. (2018). The impact of different urban dynamics on green space availability: A multiple scenario modeling approach for the region of Munich, Germany. Ecological Indicators, 93(April), 1–12.
18. Zeng, Y., Gou, M., Ouyang, S., Chen, L., Fang, X., Zhao, L., … Xiang, W. (2019). The impact of secondary forest restoration on multiple ecosystem services and their trade-offs. Ecological Indicators, 104, 248–258.

2.3 European Union documents related with ecosystems and their services

There are also several documents from the EU related with ecosystems and their services that are of major relevance to the objectives of RECOVERY, and that will be used actively in its development:

2.3.1 Mapping and assessment of ecosystems and their services

Maes, J., Teller, A., Erhard, M., Liquete, C., Braat, L. C., Berry, P., … Bidoglio, G. (2013). Mapping and Assessment of Ecosystems and their Services (MAES). An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020. Publications office of the European Union. Publications office of the European Union, Luxembourg.

MAES objective is to support the development of a coherent analytical framework to be applied by the EU and its Member States in order to ensure that consistent approaches on ecosystems and their services are used. It proposes a typology of ecosystems to be assessed and mapped and supports the maintenance and restoration of ecosystems and their services. It was developed under Action 5 of the EU Biodiversity Strategy to 2020.

2.3.2 Common international classification of ecosystem services

Haines-Young, R., & Potschin, M. B. (2018). Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. European Environment Agency, (January), 53. Retrieved from www.cices.eu

The use of CICES is proposed by MAES (2013), so that cross-reference can be made between ecosystem services.

2.3.3 CORINE Land Cover

CORINE Land Cover (CLC, 2012). Technical Guidelines. European Environment Agency, Copenhagen.

CORINE Land Cover classes are aggregated into ecosystem types for the purposes of MAES, being the most meaningful way possible to represent ecosystems combined with ecosystem-relevant information.

2.3.4 The economics of ecosystems and biodiversity

The economics of ecosystems and biodiversity (TEEB, 2010). The Economics of Ecosystems and Biodiversity. Ecological and Economic Foundations. Pushpam Kumar. London & Washington.

According to the TEEB study, the valuation of ecosystem services should be carried out in explicit ways according to the situation at hand. The TEEB study follows a tiered approach in analyzing and structuring ecosystem services valuation. It was built upon the TEEB (2008) Interim Report, European Commission, Brussels.

The valuation of the ecosystem services will be carried out in REVOVERY following the TEEB (2010) taxonomy when applicable and feasible, in order to tackle the challenges of the valuation process.

2.4 Reference documents related with EU policies

RECOVERY will enhance the delivery of the following EU policies by the coal mining industry: waste management policy (Directive 2006/21/EC on the management of waste from the extractive industries), climate and energy policies (Land use, land use-change and forestry, 2016), and biodiversity policy (EU Biodiversity Strategy, 2011).

2.4.1 Management of waste from the extractive industries

Best Available Techniques (BAT) reference document for the management of waste from the extractive industries in accordance with Directive 2006/21/EC (MWEI BREF, 2016). Joint Research Centre. European Commission. It is a reference document related with EU's waste management policy regarding the fundamental criteria for closure processes, that not necessary occurs simultaneously with the closure of a mine.

Although a draft document, it is a review of the "Reference document on Best Available Techniques for management of tailings and waste-rock in mining activities" (MTWR BREF, 2009).

It is aiming at:

1. Providing up-to-date information and data on the management of extractive waste; and
2. Supporting decision makers to take all the measures necessary to prevent or reduce as far as possible any adverse effects on the environment and human health brought about as a result of the management of extractive waste as stated in Article 4(2) of Directive 2006/21/EC.

2.4.2 EU Biodiversity Strategy to 2020

Our life insurance, our natural capital: an EU Biodiversity Strategy to 2020 (EU Biodiversity Strategy to 2020, 2011). COM (2011) 244, European Commission.

It is a reference document related with EU's biodiversity policy regarding the establishment of priorities to restore and to ensure a no net loss of biodiversity and ecosystem services.

The EU Biodiversity Strategy aims to halt the loss of biodiversity and ecosystem services in the EU and help stop global biodiversity loss by 2020. It reflects the commitments taken by the EU in 2010, within the international Convention on Biological Diversity.

2.4.3 Land Use, Land Use-Change and Forestry

Proposal for a Regulation of the European Parliament and of the Council on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry into the 2030 climate and energy framework and amending Regulation No 525/2013 of the European Parliament and the Council on a mechanism for monitoring and reporting greenhouse gas emissions and other information relevant to climate change (Land Use, Land Use-Change and Forestry, 2016). COM (2016) 479 final, European Commission.

It is a reference document related with EU's climate and energy policies regarding that accounted emissions from land use are entirely compensated by an equivalent removal of CO_2 from the atmosphere.

On 20 July 2016 the European Commission presented a legislative proposal to integrate greenhouse gas emissions and removals from land use, land use-change and forestry into the 2030 climate and energy framework. The proposal sets a binding commitment for each Member State to ensure that accounted emissions from land use are entirely compensated by an equivalent removal of CO_2 from the atmosphere through action in the sector, what is known as the "no debit rule".

3 Glossary

BAT - Best Available Techniques

CICES - Common international classification of ecosystem services

CLC - CORINE land cover

CORINE - Coordination of information on the environment

DTM - Digital Terrain Models

EEA - European Environment Agency

GIG - Główny Instytut Górnictwa

GIS - Geographic information system

HUNOSA - Hulleras del Norte S.A.

JCR - Journals Citation Report

MAES - Mapping and assessment of ecosystems and their services

MTWR BREF - Reference document on Best Available Techniques for management of tailings and waste-rock in mining activities

MWEI BREF - Best Available Techniques reference document for the management of waste from the extractive industries

NPV – Net present value

PKÚ - Palivový Kombinát Ústí, státní podnik

TEV - Total Economic Value

TEEB - The economics of ecosystems and biodiversity

TWD - Tauron Wydobycie S.A.

UNIOVI - University of Oviedo