RFCS RESEARCH PROJECT

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

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Deliverable 2.7

Assessment of ecosystem services

of Janina Mine

European Commission

Research Fund for Coal & Steel

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Executive summary

Within this Deliverable assessment of the ecosystem services for area with spatial connectivity and functional cohesion of Janina Waste Heap was carried out. The Common International Classification of Ecosystem Services (CICES)V5.1 was used. For selection ES indicators for Janina Mine case study the following criteria was set: ES should allow to carry out the assessment of mining impact and ES should reveal the potential of mine affected areas for provisioning of ecosystem services. Base on these three regulating (,water flow regulation, air quality regulation, temperature regulation) one cultural (Interactions with natural environment) and two provisioning (solar energy, mediation of waste) ES indicators were selected as representative for ES assessment. The result shows that the Janina Mine Waste Heap itself has a negative influence on regulating and cultural ES output but on the other hand their appearance could increase potential to deliver services by abiotic ecosystems like waste mitigation (storage capacity) or potential for solar power production.

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, Feranec, & Otahel, 2000; Barbara, György, Gerard, & Stephan, 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 2.7 will undergo the assessment of ecosystem services of Libiąż district where Janina Mine, property of Tauron Wydobycie S.A is located.

2 Assessment of representative ecosystem services for Libiąż (Janina Mine)

The borders of the study area were defined in the Deliverable 2.2. Baseline mapping of relevant ecosystems of Janina Mine Waste Heap. Mapping of ecosystem services and their defining was the first step to analyse the provisioning of ES in mine affected area in Libiąż, where Janina Mine operates. CORINE Land Cover classes (Bossard et al., 2000) were used to delineate, categorize and map the different ecosystems types of land cover in the study areas, and results are presented in Figure 2-1 and in Figure 2-2.

Figure 2-1 presents CORINE Land Cover classes in Libiąż (Janina Mine), and Figure 2-2 presents CLC classes in Libiąż over the orthoimage of the area.

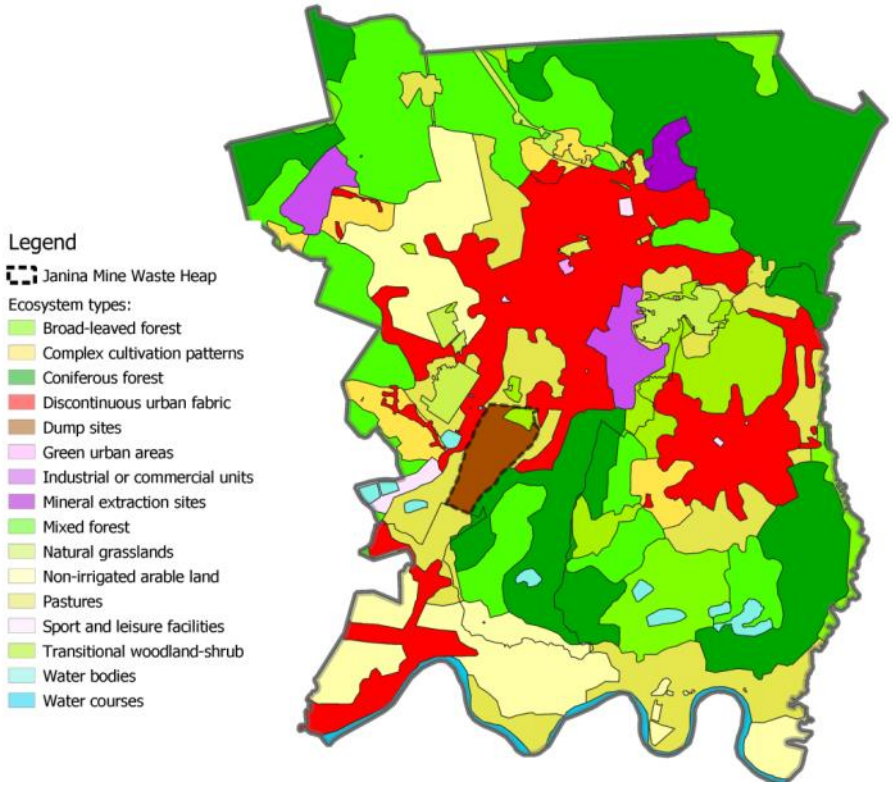

Figure 2-1. CORINE Land Cover classes of Libiąż

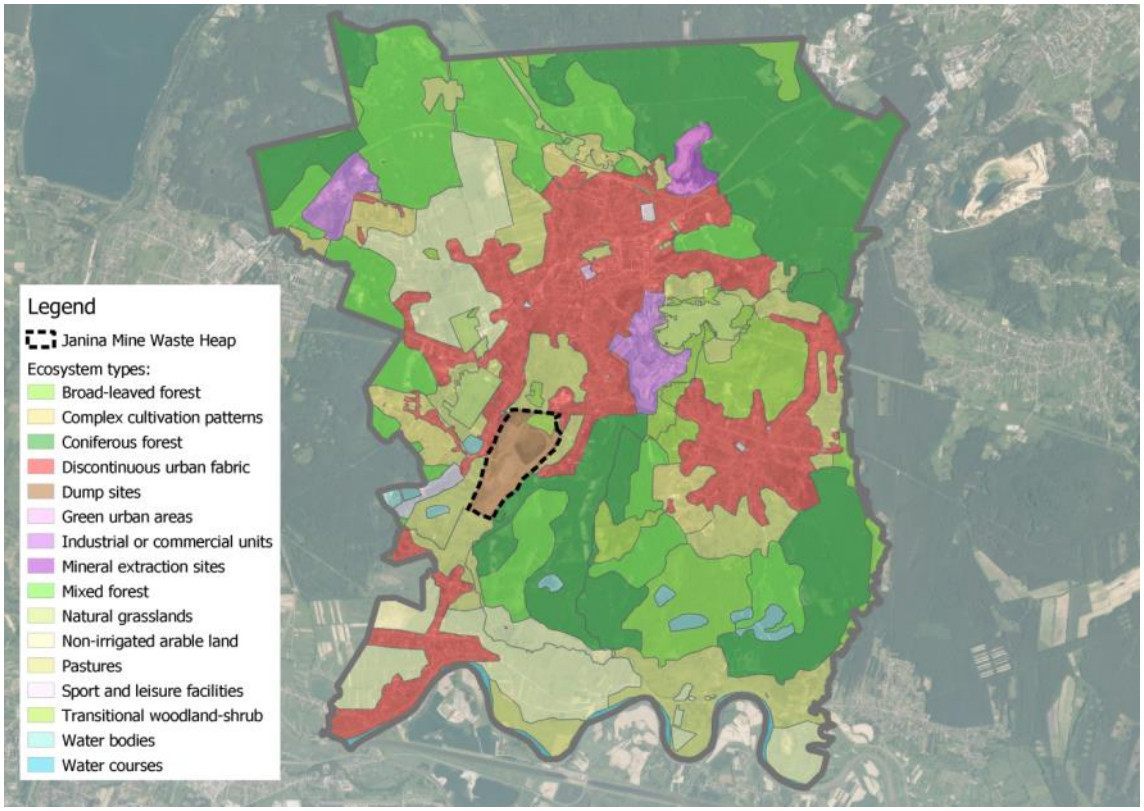

Figure 2-2. CLC classes of Janina Mine over the orthoimage of the area

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

Presented baseline mapping allowed for definition of Ecosystem Services. The definition of ES of studied area should be assessed with relation to the specific features of mine impacted areas. It should be mentioned that ecosystem services or potential of landscapes / areas for provisioning these services is very strong dependent on mining impacts and transformation of considered area.

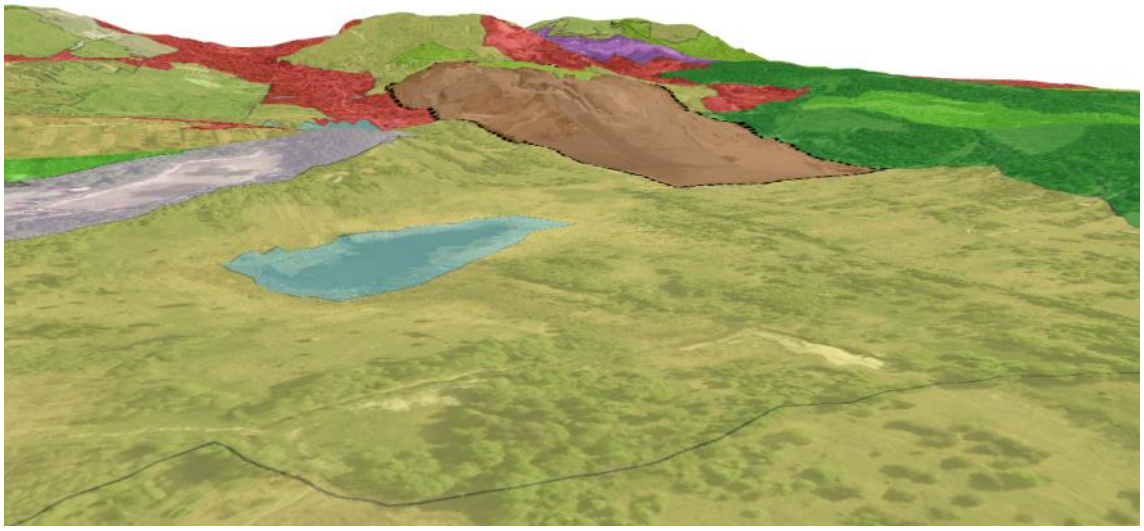

Figure 2-3. 3D image of the CLC classes

Figure 2-4 presents the spider graph of the CLC classes for Libiąż, with a significant share of the forest and semi-natural areas and a relatively low share of the artificial surfaces.

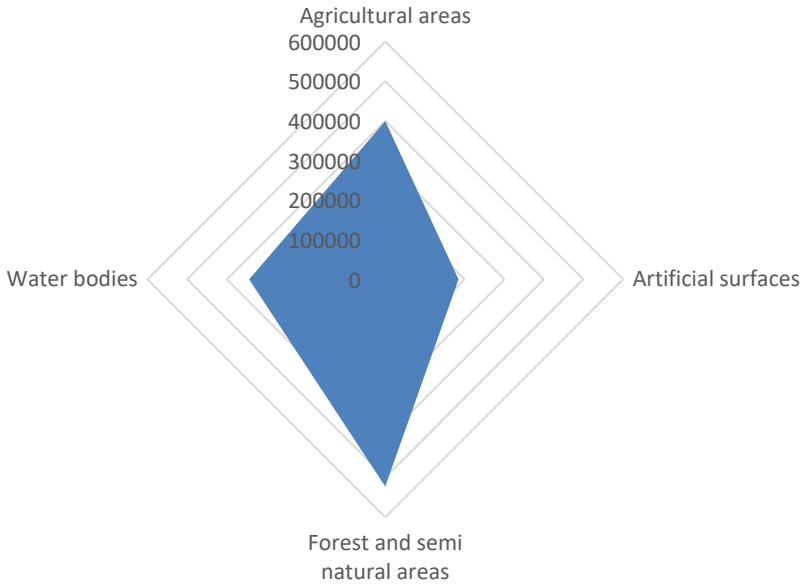

Figure 2-4. Spider graph of CLC classes for Libiąż (ha)

Mining impacts mostly related to water conditions, waste heaps, air pollution, mine subsidence and wetlands, create new ecosystem services which without mining impacts will never be served and some of ES are reduced (i.e. storage capacity potential increase while fresh water provision is reduced, solar energy production increase with relevant green area decreasing).

Mining areas and post mining areas differ from their potential for provision of ecosystem services. For selection of the most important ecosystem services for Janina Mine case study the following criteria was set :

- Ecosystem indicators should allow to carry out the assessment of mining impact.
- Ecosystem indicators should reveal the potential of mine affected areas for provisioning of ecosystem services.

After analysing of identified environmental impacts of Janina Mine Waste Heap and taking into consideration different ways of revitalization of these post mine area, the following ecosystem services (at the level of classes) were selected as important/representative for Janina Mine, with indication of the CICES V5.1 code.

2.1 REGULATING SERVICES: WATER FLOW REGULATION

Water flow regulation is delivered in the Janina case-study by all vegetated CLC classes, mainly by Coniferous forest, Broad-leaved forest, Mix Forest.

- Class level: 2213 Water flow regulation
- ES indicator: The direct water run-off
- Method: The direct run-off (QD) = Precipitation- Evapotranspiration × p/100
  p= Runoff coefficient is a dimensionless factor that is used to convert the rainfall amounts to runoff (demands on the water table deep, soil porosity, presence of vegetation, and slope of a terrain).
- Reference: Haase, D., & Nuissl, H. (2007). Does urban sprawl drive changes in the water balance and policy?: The case of Leipzig (Germany) 1870–2003. Landscape and Urban Planning, 80(1-2), 1-13.
- Main data sources:
  - ✓ Polish Geological Institute National Research Institute, First Aquifer Layer 2017
    http://epsh.pgi.gov.pl/epsh/
  - ✓ MODIS/TerraNet Evapotranspiration
    https://modis.gsfc.nasa.gov/data/dataprod/
  - ✓ COPERNICUS European Digital Elevation Model
    https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1

- Valuation by indirect methods (e.g. avoided damage cost, repair cost, replacement cost).
- Sources of uncertainty:
  - ✓ Assessment: Differing values in different climatic settings/conditions,
  - ✓ Valuation: Valuation is based on effects of lack of regulating service (assumptions of transformation, reduction of complexity of cause-effect relationships).
- Benefit for the people of the region: prevent droughts and their consequences (losses in agriculture production, cost of watering), reduce flood risks.

Figure 2-5 presents the ES delivery of water flow regulation in Libiąż district.

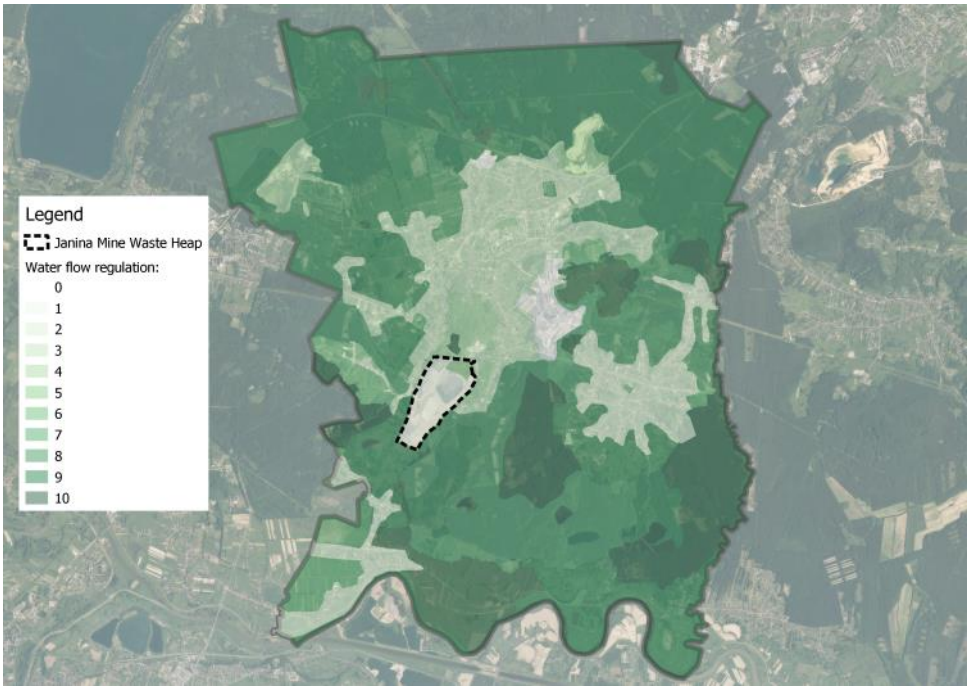

Figure 2-5. Regulating services: Water flow regulation

2.2 REGULATING SERVICES: AIR QUALITY REGULATION

Air quality regulation is delivered in the Libiąż district mainly by Coniferous forest, Broad-leaved forest, Mix Forest and transitional woodland-shrubs.

- Class level: 2.3.5.2 Regulation of chemical composition of atmosphere and oceans.
- ES indicator: Air pollution absorption (PM10 & SO2)
- Method: absorption = flux x surface x period [Mg PM10/ha].

- Reference: Tallis, M., Taylor, G., Sinnett, D., & Freer-Smith, P. (2011). Estimating the removal of atmospheric particulate pollution by the urban tree canopy of London, under current and future environments. Landscape and Urban Planning, 103(2), 129-138.
- Main data sources:
  - ✓ atmospheric precipitation: https://danepubliczne.imgw.pl/
  - ✓ Air quality : www.ongeo.pl
- Valuation by indirect methods (avoided health damage costs).
- 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)
- Benefit for the people of the region: improve health, deacreasing cost of health care

Figure 2-6. Regulating services: Air quality regulation presents the ES delivery of air quality regulation in Libiąż district.

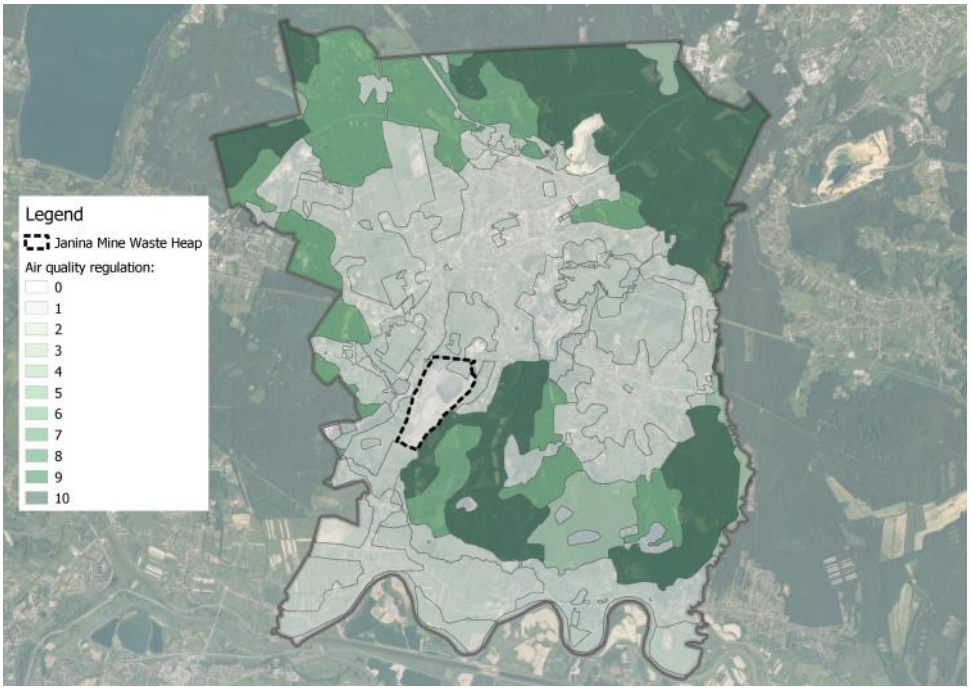

Figure 2-6. Regulating services: Air quality regulation

2.3 REGULATING SERVICES: CLIMATE REGULATION

Climate regulation is delivered in the Janina case-study by Coniferous forest, Broad-leaved forest, Mix Forest, Water bodies, Transitional woodland/shrubs and Pastures.

- Class level: 2.2.6.2, Regulation of temperature
- ES indicator: Thermal emissivity
- Method: LST from Landsat 8 Thermal Band
- References:
  - ✓ 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
  - ✓ Haase D (2009) Effects of urbanisation on the water balance - A long-term trajectory. Environ Impact Assess Rev 29:211–219. https://doi.org/10.1016/j.eiar.2009.01.002
- Main data sources:
  - ✓ ESA Earth Observation https://eo-sso-idp.eo.esa.int/
- 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)
  - ✓ Valuation: Valuation is based on effects of lack of regulating service (assumptions of transformation, reduction of complexity of cause-effect relationships)
- Benefit for the people of the region: degreasing consequences of urbun heat islands process: anxiety and sleep, social functioning, and depression (Mirzaei, M., Verrelst, J., Arbabi, M., Shaklabadi, Z., & Lotfizadeh, M. (2020). Urban Heat Island Monitoring and Impacts on Citizen's General Health Status in Isfahan Metropolis: A Remote Sensing and Field Survey Approach. Remote Sensing, 12(8), 1350)

Figure 2-7 presents the ES delivery of air quality regulation in Libiąż district.

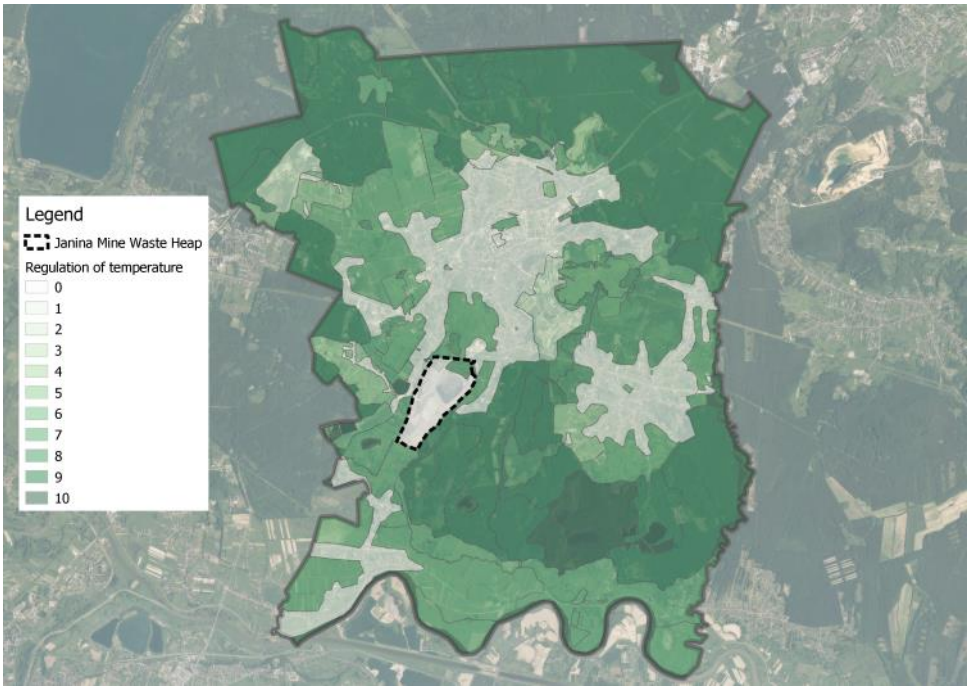

Figure 2-7. Regulating services: Regulation of temperature

2.4 CULTURAL SERVICES: INTERACTIONS WITH NATURAL ENVIRONMENT

The biophysical characteristics or qualities of species or ecosystems (landscapes) that enable activities promoting health, de-stressing and nature-based recreation in Janina case study is mostly connected with forest ecosystems, water bodies and natural grasslands.

- Class level: 3.1.1.2, Interactions with natural environment
- ES indicator: biotopes values
- Method: Valuation points according to eight ecological characteristics, each of them with the potential point value from one to six points:
  - ✓ biotope matureness (points according to the phylogenetic age of species)
  - ✓ biotope naturalness (6 points to completely natural, 1 point to anthropogenic)
  - ✓ diversity of biotope structures (6 p. to all vegetation layers)
  - ✓ diversity of biotope species (points according to the number of autochthonic species)
  - ✓ rareness of biotope (points according to the geographical and climatic uniqueness, scarcity, frequency, extent)
  - ✓ rareness of species of biotope (points according to the number of rare and redlist species)

  - ✓ sensitivity (vulnerability) of biotope (points according to the rate of vulnerability through the change of habitat conditions)
  - ✓ threat to number and quality of biotope (points according to the dependency on the change of rate of anthropogenic activities and conditions)
- Reference: Seják, J., Dejmal, I., Petricek, V., Cudlin, P., Michal, I.,Cerny, Cudlinova, E. (2010). Method of monetary valuation of territorial ecological functions. Mscr., JE Purkyne University, Ústí nad Labem.
  https://fzp.ujep.cz/projekty/bvm/bvm.pdf
- Main data sources:
  Forest Data Bank
  https://www.bdl.lasy.gov.pl/portal/en
- Valuation by indirect methods (e.g. avoided cost – health improving).
- Sources of uncertainty:
  - ✓ Assessment: is based on characteristics of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions.
  - ✓ Valuation: is based on decreasing of health care system costs – complex interaction difficult to valuate.
- Benefit for the people of the region: positively related wellbeing and pro-environmental behaviours (Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., & Burt, J. (2020). Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. Journal of Environmental Psychology, 68, 101389)

Figure 2-8 presents the ES delivery of interactions with natural environment in Libiąż district.

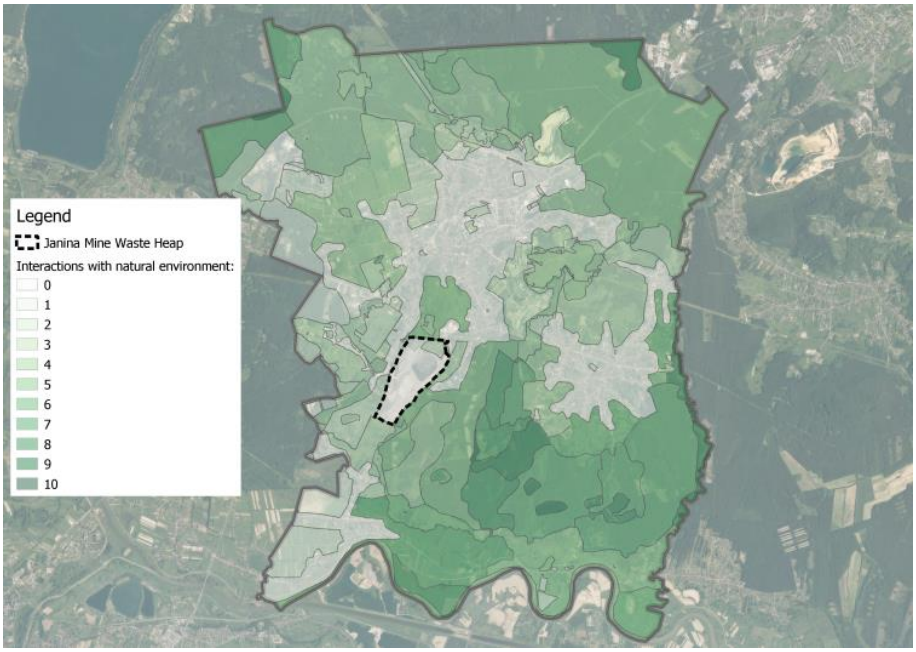

Figure 2-8 Cultural services: Interactions with natural environment

2.5 PROVISIONING SERVICES: SOLAR POWER

Solar energy could be deliver in the Libiąż case-study only by open area like: Dump sites, Complex cultivation patterns, Non-irrigated arable land and Pastures. The specific feature of this services is that solar power needs operational capacity of dedicated installation – PV systems. Provisioning of this ES itself by the natural environment is possible to calculate, but in terms of "the benefits people obtain from ecosystems" (Millennium Ecosystem Assessment, 2005), the potential electric power from solar power is assessed.

- Class level: 4.3.2.4, Solar power
- ES indicator: electric power production
- Method: potential electric power = open area with south, east and west exposure x solar PV energy output
- Reference: Casalegno, S., Bennie, J. J., Inger, R., & Gaston, K. J. (2014). Regional scale prioritisation for key ecosystem services, renewable energy production and urban development. PloS one, 9(9). https://doi.org/10.1371/journal.pone.0107822
- Main data sources:

- ✓ COPERNICUS European Digital Elevation Model
  https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1
  https://www.mapa.gob.es/es/ganaderia/estadisticas/mercados_agricolas_ganaderos.aspx

- Valuation by direct methods (e.g. market prices) or assessment tools (European Commission > EU Science Hub > PVGIS > Interactive tools): https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html
- Sources of uncertainty:
  - ✓ Assessment: seasonal changes depending on weather conditions.
  - ✓ Valuation: changing market prices depending on demand /supply, elasticity of demand/supply, substitution, etc.
- Benefit for the people of the region: creating a new workplaces, reduces the cost of electric energy.

Figure 2-9 presents the ES potential for delivery solar power in Libiąż district.

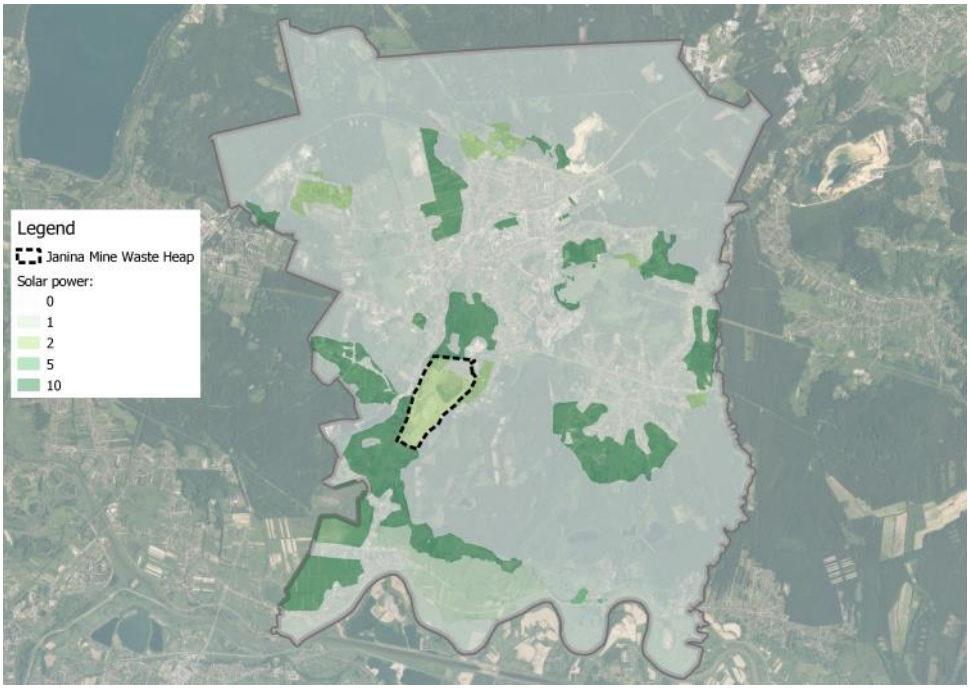

Figure 2-9. Provisioning services: Solar power

2.6 PROVISIONING SERVICES: MEDIATION OF WASTE

Potential for mediation of waste could be delivered in the Libiąż case-study only by mining impacted area like Damps (waste heap) and Mineral extraction sites (open pit mines of raw materials under rehabilitation or closure).

- Class level: 5.1.1.2, Mediation of waste
- ES indicator: Storage capacity.
- Method: estimation of available volume with waste mediation potential, with relation to density of stored wastes.
- Reference: Burkhard, B., & Maes, J. (2017). Mapping ecosystem services. Advanced books, 1, e12837.
- Main data sources:
  - ✓ Tools for 3D terrain measurement https://mapy.geoportal.gov.pl/
- Valuation by direct methods (e.g. market prices of storage of wastes in open pits or waste heaps per tonne).
- Sources of uncertainty:
  - ✓ Assessment: possibility of waste storage (i.e. negative impact on water conditions in storage area), limited capacity of the waste storage area and limited provision in a spatial context.
  - ✓ Valuation: changing market prices.
- Benefit for the people of the region: industry development (saving and creating workplaces)

Figure 2-10 presents the ES potential for delivery Mediation of waste in Libiąż district.

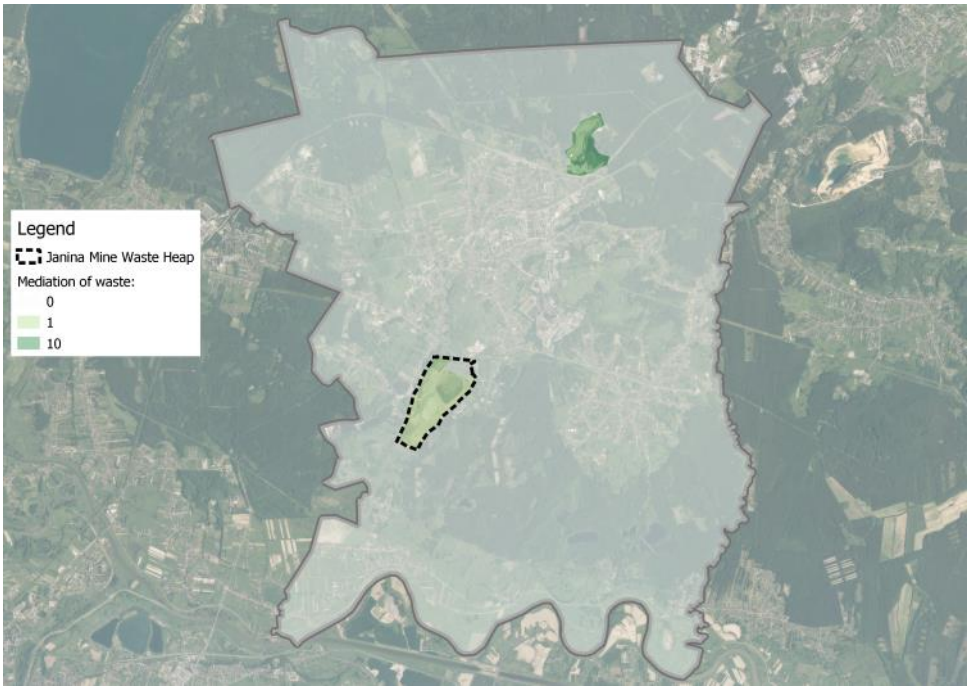

Figure 2-10. Provisioning services: Mediation of waste

3 Conclusions and lessons learnt

The results of Ecosystem Services (ES) assesment revealed that Libiąż district area is impacted by mining activity and the Janina Mine Waste Heap itself has a negative influence on ecosystem services output. 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 Janina Waste Heap area to forest, semi natural areas and agriculture areas CLC classes have low ability to deliver water flow regulation, air quality regulation, temperature regulation and cultural services. When analysing other services it seems that the mine waste heap could increase potential to deliver services by abiotic ecosystem like waste mitigation (storage capacity) or potential for solar power production. These services have in fact monetary value and could mitigate environmental impacts (like use of renewable energy and reduction of CO_2 emission) or increase other negative influences (i.e. acid drainage generation).

- Lessons learnt from results and the output for next step of work in RECOVERY are that:setting appropriate criteria for ES indicators selection is very important in ES assessment concept. In the proposed approach ES indicators that allow environmental impact assessment on mining activity and to identify mine-affected areas potential for provisioning of ES were selected.
- ES indicators should also cover regulating, cultural and provisioning types, but ther number should be as lower as it is psssible, because accounting ES indicators values is time consuming, needs GIS skiils and couldn`t be done in automatic way.
- In the case of Libiąż district three regulating, one cultural and two provisioning ES indicators were selected as representative for ES assessment. These approach allows to reach the goals of the task for Janina Waste Heap case study.

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. In the nex step (task T3.4 Formulating alternative actions) he ecosystem services concept and their assessment will be applied to different restoration activities and different future redevelopment scenarios for case study area. 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

UNSD - United Nations Statistical Division

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