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

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Deliverable 2.10

Assessment of ecosystem services of Mibrag Mines

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Executive Summary

The document reports the deliverable 2.10 of the RFCS project “Recovery of degraded and transformed ecosystems in coal mining-affected areas”. The report demonstrates the assessment of ecosystem services for the former pit mining area south of Leipzig in eastern central Germany (Mibrag Mines study area).

The assessment of the relevant ecosystem services is based on the land cover identified in the baseline mapping from the previous deliverable. Ecosystem services are classified according to the Common International Classification of Ecosystem Services (CICES) ensuring a scientifically developed framework, which is widely accepted for ecosystem service assessments. Three categories of ecosystem services are applied in the classification. Provisioning services are tangible outputs of ecosystems that can be readily transformed into marketable goods, such as food from crops or livestock or fibre from trees. Regulating services refer to ecological processes that regulate environmental conditions to the benefit of humans. Carbon sequestration or air purification are examples for regulating services. The third category, cultural ecosystem services, refers to ecosystem outputs that sustain cultural practices, which also includes relaxation or mental recovery.

The relevance of the ecosystem services is guided by the importance of the respective ecosystem services for the post mining development of the landscape. The relevant ecosystem services have to provide economic alternatives for the mining based economy, to support the economic viability of the transformation process. The relevance of the regulating services is guided by the environmental conditions from the transformed mining landscape, which have to be regulated to support the living conditions in the post mining area. The opportunity to contribute to the regulation of the global challenge of climate change was also taken into consideration. The cultural services relevant for the study area contribute to the aesthetic restoration of the post-mining landscape. The relevant cultural services can also provide economic opportunities based on the touristic attractiveness of the reclaimed post-mining landscape.

The provisioning services in the assessment represent the base for economic alternatives to the mining related economy. For the Mibrag Mines area, the agricultural and forestry production represent the dominant provisioning services in the post-mining land use. The regulating services assessed are local climate regulation to benefit the nearby large city of Leipzig, and global carbon sequestration to contribute to tackling the challenge of climate change and lower the “carbon-footprint” of the former mining activities. As cultural ecosystem services the recreation potentials of the post-mining landscape are assessed. The transformed landscape features novel landscape elements, such as lakes, that are attractive for the residential population as well as tourists. This

way the cultural ecosystem services not only encourage the locals to remain in the are as well as providing job opportunities in the touristic sector.

1 Introduction

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

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

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

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

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

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

Deliverable 2.10 will undergo the assessment of ecosystem services of Mibrag Mines area, south of the city of Leipzig (Germany).

2 Assessment of representative ecosystem services for Mibrag Mines area

Figure 2-1 presents CORINE Land Cover classes in the Mibrag Mines area, and Figure 2-2 presents CLC classes in the Mibrag Mines area over the Orthoimage of the area.

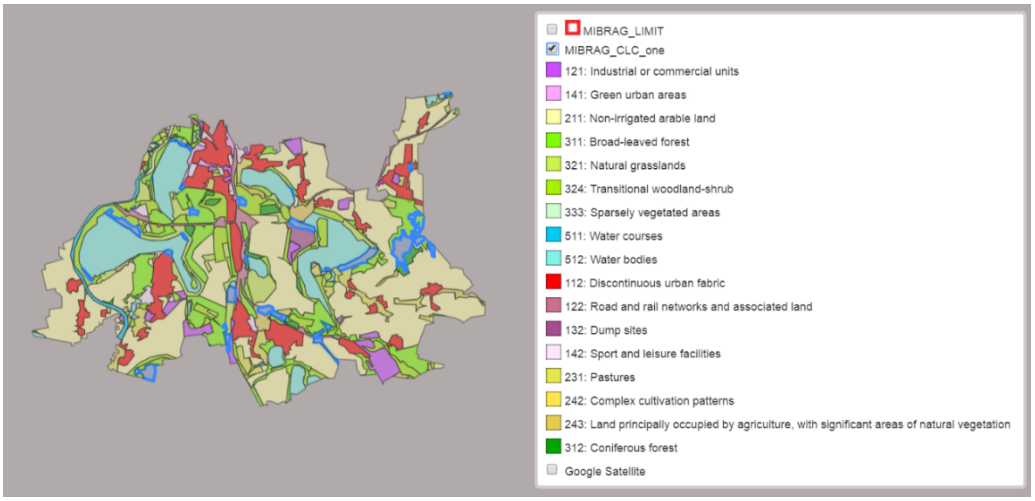

Figure 2-1. CORINE Land Cover classes in Mibrag Mines area.

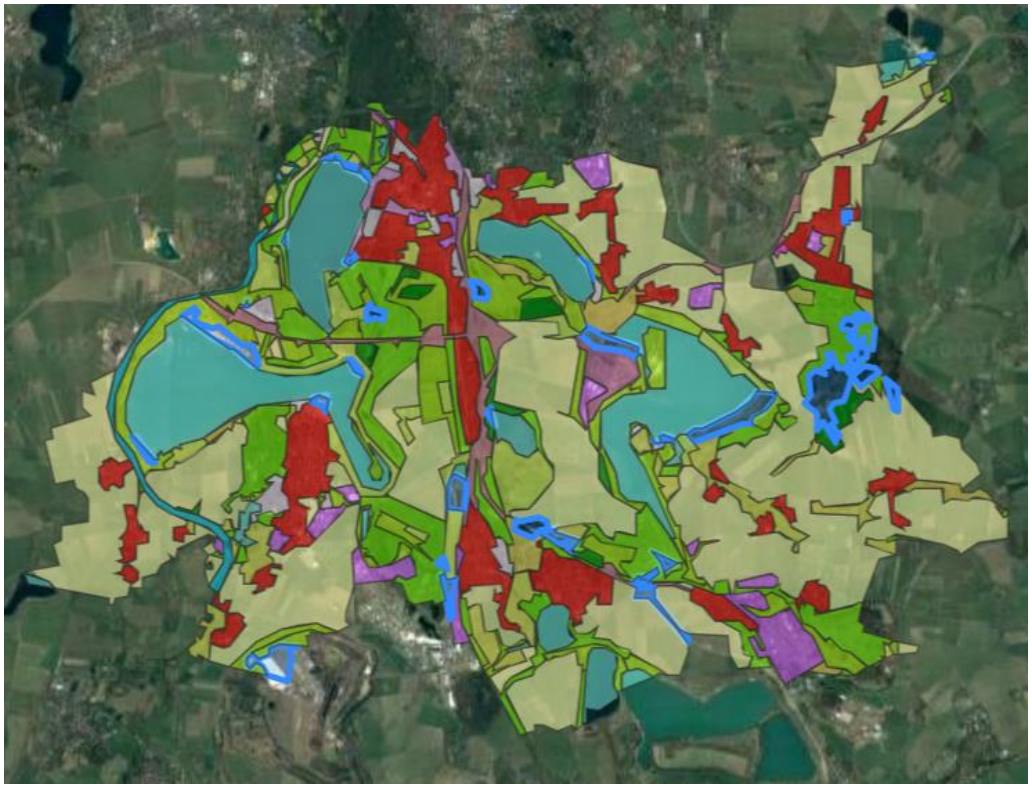

Figure 2-2. CLC classes in Mibrag Mines area over the orthoimage of the area

Figure 2-3 presents the spider graph of the CLC classes for Mibrag mines, with a strong projection over the agricultural areas, something usual in the western Saxony region.

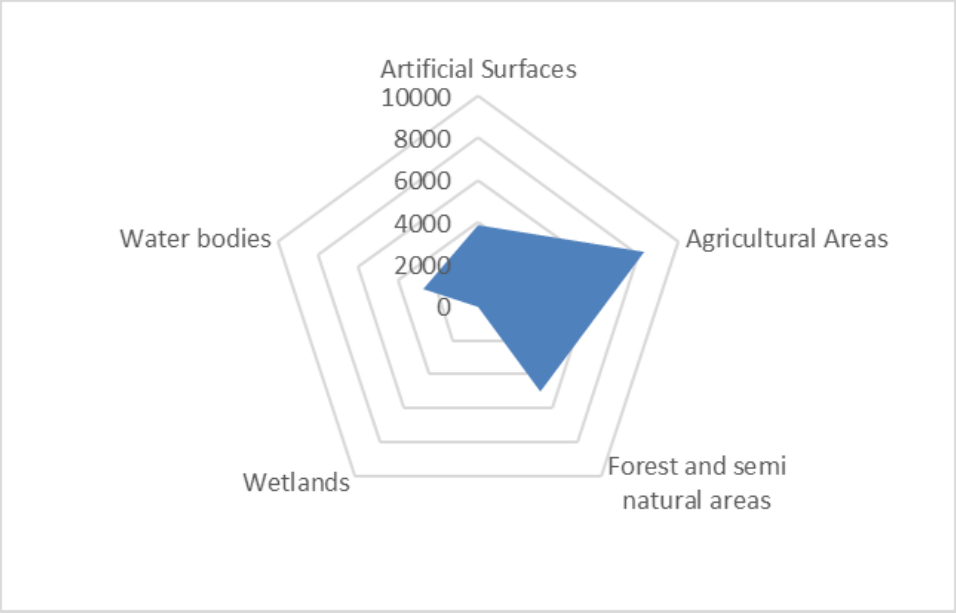

Figure 2-3. Spider graph of CLC classes for Mibrag Mines area (ha)

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

2.1 PROVISIONING SERVICES: FOOD PROVISION

Food provision in the Mibrag Mines region south of the city of Leipzig is mainly delivered by non-irrigated arable land and to a smaller extend by pastures. The pastures and parts of the non-irrigated arable land in the Mibrag mines area are used to produce silage and fodder for animals. Separation of these land-uses is not possible within the frame of this assessment. The different agricultural land-uses are treated as ES: cultivated terrestrial plants for nutritional purposes. A mean value for the seven most common crops for 10 years (2008-2018) was calculated for non-irrigated arable land. For Pastures the production of grass to feed livestock was applied. For CLC 243 the mean value of all possible crops on non-irrigated arable land and the yield of pastures was calculated and multiplied by 0,5 the median of the proportion of natural areas according to the definition of the CLC class 243 (Kosztra et al., 2017).

- Class level: 1.1.1.1 cultivated terrestrial plants for nutritional purposes.
- ES indicator: agricultural production.
- Method: agricultural yield in t ha^{-1} $year^{-1}$ (10 years mean)

- Reference: Baró, F., Gómez-Baggethun, E., & Haase, D. (2017). Ecosystem service bundles along the urban-rural gradient: Insights for landscape planning and management. Ecosystem Services, 24, 147–159. https://doi.org/10.1016/j.ecoser.2017.02.021
- Main data sources:
  - ✓ Statistisches Landesamt des Freistaates Sachsen (2019). Statistischer Bericht – Bodenhaupterhebung im Freistaat Sachsen 2019, C I 2 – j/19. (xlsx-file) https://www.statistik.sachsen.de/html/508.htm (in German) (last access: 12.03.2020)
  - ✓ Statistisches Landesamt des Freistaates Sachsen (2018). Statistischer Bericht – Bodennutzung und Ernte im Freistaat Sachsen – Feldfrüchte, Baumobst, Strauchbeeren und Gemüse 2018, C II 2 – j/18. (xlsx-file) https://www.statistik.sachsen.de/html/508.htm (in German) (last access: 12.03.2020)
- Valuation by direct methods (e.g. market prices).
- Sources of uncertainty:
  - ✓ Assessment: seasonal changes depending on weather conditions.
  - ✓ Valuation: changing market prices depending on demand /supply, elasticity of demand/supply, substitution, etc.

2.2 PROVISIONING SERVICES: FIBRE PROVISION

Fibre provision in the area is delivered by forests. Forests include broad-leaved forests, coniferous forests and mixed forest stands. Forest is also present as transitional forest-shrub, but these forest ecosystems are not relevant for fibre production.

- Class level: 1.1.5.2 Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)
- ES indicator: timber stock (harvestable volume under bark)
- Method: forest yield in $m^3\ ha^{-1}\ a^{-1}$
- References: Larondelle, N., Haase, D. (2012). Valuing post-mining landscapes using an ecosystem services approach – An example from Germany. Ecological Indicators 18, 567-574.
- Main data sources:
  - ✓ Dritte Bundeswaldinventur (Third National Forest Inventory) (2012). Database: timber stock (harvestable volume under bark) of used stand [$m^3\ ha^{-1}\ a^{-1}$] by Land and tree species group. https://bwi.info/inhalt1.aspx
- Valuation by direct methods (e.g. market prices).
- Sources of uncertainty:
  - ✓ Assessment: seasonal changes depending on weather conditions.
  - ✓ Valuation: changing market prices depending on demand /supply, elasticity of demand/supply, substitution, etc.

2.3 REGULATING SERVICES: LOCAL CLIMATE REGULATION

Climate regulation in the Mibrag Mines area case-study is delivered by Broad-leaved, coniferous and mixed forest, Transitional woodland/shrubs and Natural grassland. The potential evapotranspiration serves as indicator for the cooling effect of vegetation and, for the study area, it is correlated with the surface emissivity values (Schwarz et al., 2011). The f-ETP is the potential evapotranspiration adjusted by the land use (the multiplier is applied to the value for potential evapotranspiration) is assessed for each polygon. For port areas (not assessed by Schwarz et al., 2011) a proportion of 35% water and 65% sealed surface was applied (similar to the discontinuous urban fabric calculation in Schwarz et al., 2011).

- Class level: 2.2.6.2 Regulation of temperature and humidity, including ventilation and transpiration.
- ES indicator: Potential evapotranspiration (f-ETP) mm ha^{-1} a^{-1}.
- Method: Evapotranspiration adjusted by land use f-ETP.
- 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
- 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)

2.4 REGULATING SERVICES: CARBON SEQUESTRATION

In the Mibrag mines area case-study carbon sequestration is delivered by Broad-leaved, coniferous and mixed forest and Transitional woodland/shrubs. Pastures are not included here because they are considered a Provisioning service, thus being incompatible with carbon sequestration.

- Class level: 2.2.6.1 Regulation of chemical composition of atmosphere and oceans.

- ES indicator: Above-ground carbon storage ha^{-1}.
- Method: Above-ground carbon storage linked to land use [MgC/ha].
- Reference: Strohbach, M. W., & Haase, D. (2012). Above-ground carbon storage by urban trees in Leipzig, Germany: Analysis of patterns in a European city. Landscape and Urban Planning, 104(1), 95–104. https://doi.org/10.1016/j.landurbplan.2011.10.001
- Main data sources:
  - ✓ Liski, J., Lehtonen, A., Palosuo, T., Peltoniemi, M., Eggers, T., Muukkonen, P., & Mäkipää, R. (2006). Carbon accumulation in Finland's forests 1922-2004 - An estimate obtained by combination of forest inventory data with modelling of biomass, litter and soil. Annals of Forest Science, 63(7), 687–697. https://doi.org/10.1051/forest:2006049
  - ✓ EU Emissions Trading System (EU ETS). https://ec.europa.eu/clima/policies/ets_en
- Valuation by direct methods (carbon dioxide pricing is possible).
- 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)

The above-ground carbon storage for the region was assessed within the paper by Strohbach & Haase (2012). So the values from this source were used. The values for CLC class 243 were calculated using the above-ground carbon storage value for Broad-leaved trees, the value was multiplied by 0,5 the median of the proportion of natural areas according to the definition of the CLC class 243 (Kosztra et al., 2017).

2.5 CULTURAL SERVICES: RECREATION

Physical and experiential interactions with natural environment depend on characteristics of living systems are provided by the lakes, which were formed from the former open-cut mining pits. The forest areas are also characterized as recreational areas by the forestry service of the federal state of Saxony (Staatsbetrieb Sachsenforst, 2010), which also gives a classification of the forests with recreation function based on the proximity to settlements and estimation of visitors per ha per year (Staatsbetrieb Sachsenforst, 2010, pp. 49-53). For the lakes the numbers of visitors was more difficult to estimate. For the for large, former mining pit lakes visitors number are presented for the two which are closest to the city of Leipzig (Cospudener See and Markkleeberger See). These were assessed with their respective estimated number of visitors per year, The other two large lakes (Zwenkauer See and Störmthaler See) are more recent and

farther away from the city of Leipzig, and their water-touristic infrastructure is still under development (Wirtschaftsförderungsgesellschaft Anhalt-Bitterfeld & Stadt Leipzig, 2014). These lakes are assumed to attract about 2/3rds of the mean value of the visitors. The smaller lakes within the study area are either embedded in the forests with recreation value (in this case the number of visitors for the adjacent forest is applied) or they have no relevant recreational potential and are not within the range of a forest with recreational value (in this case the visitor number is zero).

- Class level: 3.1.1.1 Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions.
- ES indicator: Number of visitants.
- Method: Number of visitants year^{-1}.
- Reference: Baró, F., Palomo, I., Zulian, G., Vizcaino, P., Haase, D., & Gómez-Baggethun, E. (2016). Mapping ecosystem service capacity, flow and demand for landscape and urban planning: A case study in the Barcelona metropolitan region. Land Use Policy, 57, 405–417. https://doi.org/10.1016/j.landusepol.2016.06.006
- Main data sources:
  - ✓ Cospudener See – Leipzigseen (German) https://www.leipzigseen.de/die-seen/cospudener-see
  - ✓ Sachsen Fernsehen: Markkleeberger See gehört zu den 10 Lieblingsseen Deutschlands (German) https://www.sachsen-fernsehen.de
  - ✓ Staatbetrieb Sachsenforst (2010). Waldfunktionenkartierung - Grundsätze und verfahren zur Erfasssung der besonderen Schutz- und Erholungsfunktionen des Waldes im Freistaat Sachsen. (German) https://publikationen.sachsen.de/bdb/artikel/16532
  - ✓ Staatsbetrieb Geobasisinformaation und Vermessung Sachsen (GeoSN) Geoportal Sachsenatlas https://geoportal.sachsen.de
- Valuation by indirect methods (e.g. stated or revealed preference, etc.).
- Sources of uncertainty:
  - ✓ Assessment: definition of ES is closely connected to cultural values.
  - ✓ Valuation: Valuation is based on cultural values, which are to certain, extend subjective, and based on the cultural background of the stakeholders.

3 Conclusions and lessons learnt

The Assessment of ecosystem services for the Mibrag Mines area south of Leipzig shows the ecosystem service potentials of a post-mining landscape in which the mining activities ended only recently.

The landscape was heavily influenced by the open-cut mining activities, which led to major alterations of the landscape, especially regarding water bodies. The water bodies now form a visible element of the landscape which on the one hand bears reminiscence to the long mining traditions which formerly constituted an important segment of the regional economy which also had an impact on the energy generation of the German Democratic Republic before the reunification in 1990 and even afterwards. Even though the mining industry in central Germany lost importance after the reunification the regional importance of lignite mining can still be felt in the area.

Nowadays the natural and semi-natural areas are providing a range of ecosystem services to the population of the local settlements as well as the city of Leipzig, in all approximately 646 000 people, not counting the numerous visitors which are attracted by what is called the “new lakes landscape” south of Leipzig.

In the Mibrag Mines area south of Leipzig agricultural areas make up most of the land-use. Non-irrigated arable land and Pastures serve the need of feeding the people. The provision of food from the agricultural ecosystems is therefore an important factor for the local economy and the population of the settlements in the region including the City of Leipzig.

Forested and semi natural areas make up another big proportion of the land cover areas in the Mibrag Mines area south of Leipzig. Forests, with the majority of Broad-leaved forests provide the most diverse range of ecosystem services among the ecosystems in the region. Forest provide fibre as raw materials for example for construction of the production of paper of all kinds and provide opportunities for active recreation. In addition forests influence the local and regional climate by cooling through evapotranspiration as well as the global climate by carbon sequestration. The latter two ecosystem services are also provided by the two other frequent land-covers within the class of forests and semi-natural areas, which are transitional forest-shrub and natural grasslands, even though to a lesser degree than by forests, which is due to their lower ecosystem productivity. However, transitional forest-shrub are typical ecosystems for post-mining areas and they have the potential to provide more ecosystem services once they reach their climax state in the form of forest areas.

The last important land-cover type are water bodies, i.e. the new lakes in a landscape formerly devoid of lakes. These lakes are considered important elements of the present recreational and touristic infrastructure with growing potential in the future.

The assessment methods are based on the CICES, version 5.1. The CICES is designed to capture as many possible ecosystem services as possible. In the case of provisioning services the division between the classes is comprehensible, the description of the ecosystem services is easily applicable to the land cover conditions of industrialized countries. The categories of regulating services are less clear and the categories of cultural ecosystem services are least clear.

Another challenge of applying the CICES methods are alternative ecosystem services from the same land cover. For example, the provision of food and energy crops can both be realized on the same non-irrigated agricultural area. Another example are carbon sequestration and fibre production by forest areas, which can only achieved at the expense of the other respective service. Other ecosystem services can both be realized without interference, for example the ecosystem service of microclimate regulation and recreation from green urban areas or urban forest.

The above-mentioned challenges can be met by considering the local context of the ecosystem services. The local demand for ecosystem services provides a good guideline to identify the ecosystem services that are relevant in the local context. The issue of rivalling ecosystem services should be considered in the selection of ecosystem services for the assessment. However, at this stage of assessment, the assessed ecosystem services represent the benefits that can be derived from the respective land cover classes. Which benefit will be derived from the land cover finally depends on a variety of factors depending on local as well as regional and even global socio-economic conditions. Despite the ongoing academic discussion about ecosystem services, the proposed method for the assessment of ecosystem services delivers good results and is easy to comprehend and apply.

4 Glossary

CICES - Common International Classification of Ecosystem Services

CLC - CORINE Land Cover

CORINE - Coordination of information on the environment

EEA - European Environment Agency

ES – Ecosystem Service

GIS - Geographic information system

SEEA - System of Environmental and Economic Accounting

UBER – Humboldt-Universität zu Berlin

UNSD - United Nations Statistical Division

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