# HyMoCARES Project

## WPT3. EFFECTS OF HYDROMORPHOLOGICAL MANAGEMENT AND RESTORATION MEASURES

# Report regarding the effects on ES of management/restoration works, applying the overall ES framework

## Case study: Drau (Kleblach)

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| **Project:** HyMoCARES |
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## 1 Case studies

### 1.1 Drau river

The case study site is a restored reach of the Drau River near the village Kleblach-Lind (Figure 1) in the Upper Drau valley in Carinthia, Austria. The section examined in the course of the ecosystem service analysis is 1.8km long.
For a detailed description of the study site see the Technical Notes.

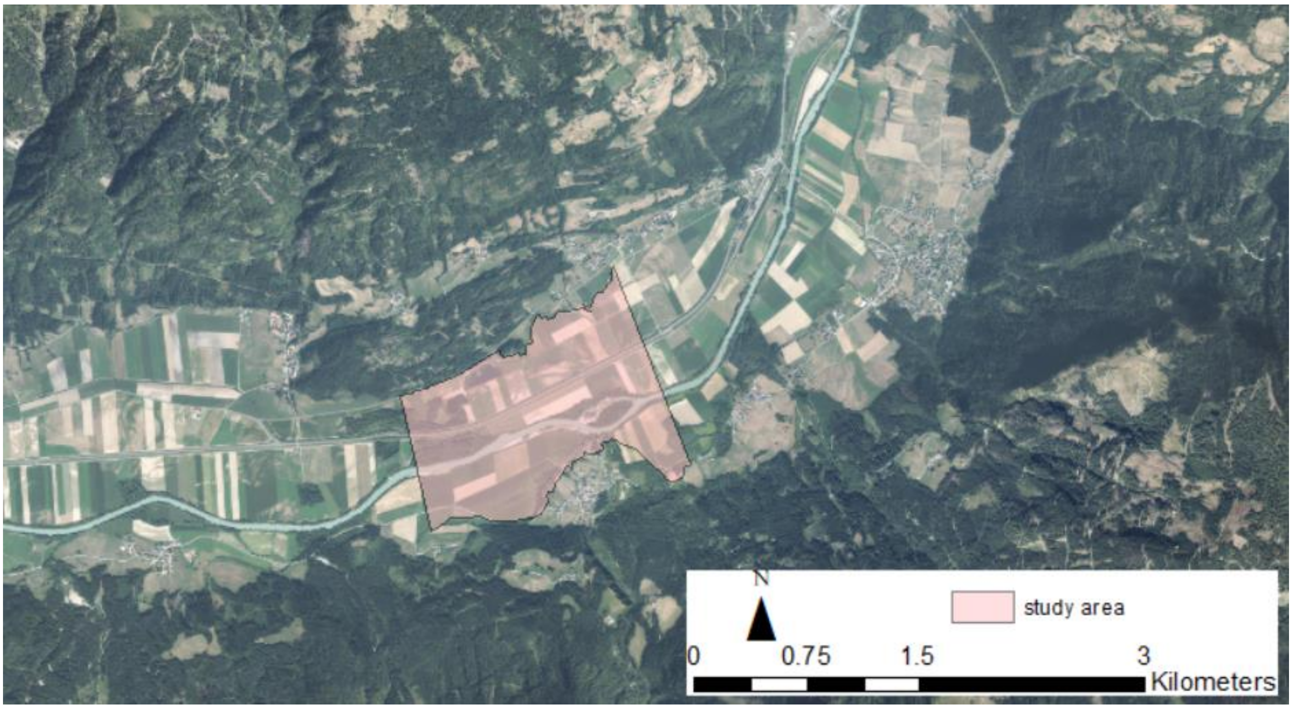


**Figure 1 River Drava study area at restoration site Kleblach**

The outer boundaries for the ES-Analyses have been determined by the lateral extent of the flooded area of a 100-year flood, with the total area comprising 1.72 km². Due to its short length, this river reach was not divided into subunits for this assessment.

The restoration action considered in this analysis is channel widening, which affects the functions river morphology, lateral connectivity, hydraulics, sediment continuity, vertical connectivity, physical habitat and biotic communities (Figure 2).

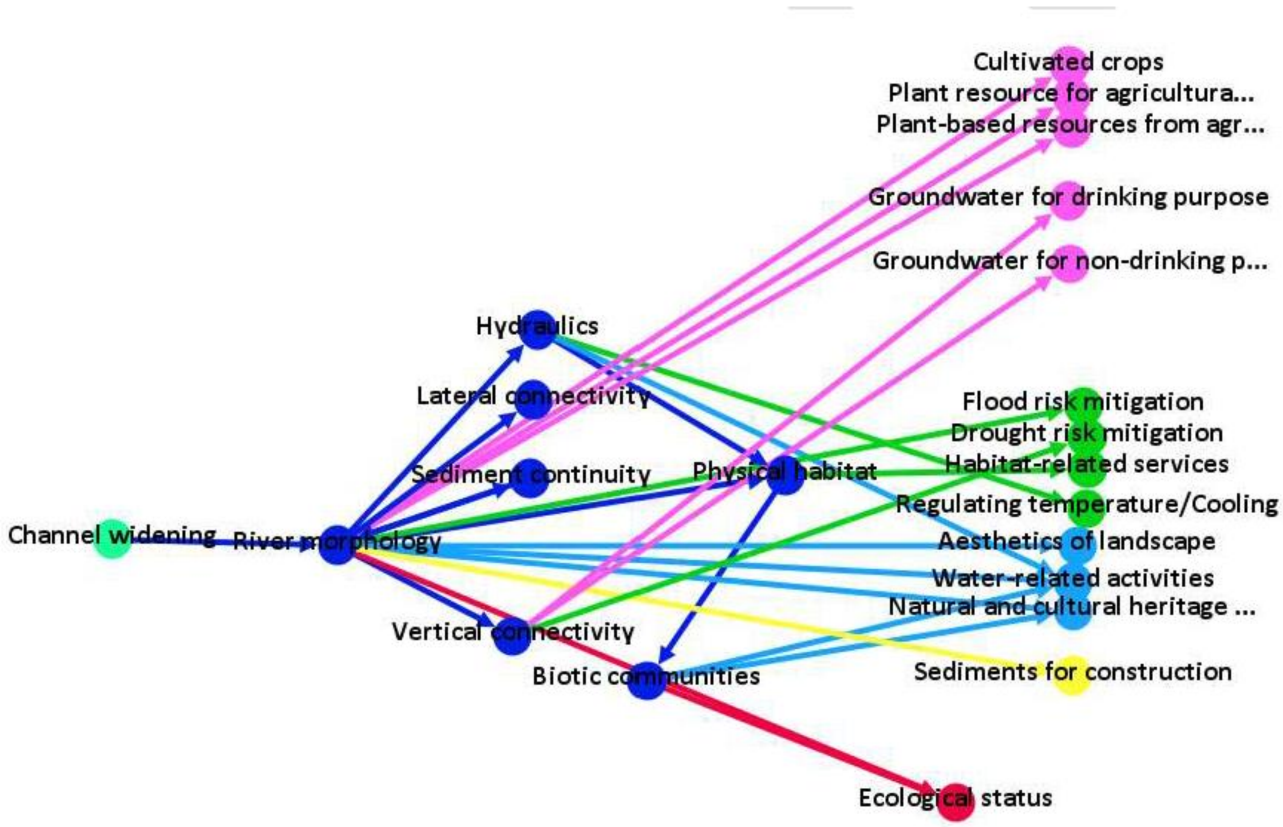


**Figure 2 Restoration measure channel widening with the associated functions and ecosystem services**

From the list of tools suggested by the HyMoCARES framework, those used in this analysis are listed in Table 1:

**Table 1 Tools used in the analysis**

| Tool | Processes assessed |
|---|---|
| Chevo | River morphology, lateral connectivity |
| HyMoLink | River morphology, lateral connectivity, physical habitat |

# 2 ES selection

## 2.1 Drau River

Table 2 lists the ecosystem services described in the framework and highlights those affected by channel widening and in terms of relevance for this study site.

**Table 2** River ecosystem services suggested in deliverable DT.1.2 (second column), highlighted as relevant for the case studies (third column) with some additional comments (fourth column).

| Ecosystem service | D.T.1.2.1 | Relevant | Comments |
|---|---|---|---|
| Cultivated crops | X | | |
| Plant resources for agricultural use - Pasture | X | | |
| Surface water for drinking purpose | | | |
| Ground water for drinking purpose | X | | |
| Surface water for non-drinking purposes in industry and agriculture | | | |
| Ground water for non-drinking purposes in industry and agriculture | X | | |
| Plant-based resources from agriculture, short rotation coppice, forestry | X | | |
| Retention of nutrients | | X | |
| Reduction of greenhouse gas emission / carbon sequestration | | | |
| Flood risk mitigation | X | X | **Not assessed in this analysis due to lack of data** |
| Drought risk mitigation | X | X | |
| Soil formation in floodplains | | | |
| Regulating temperature/Cooling (water bodies and ground) | X | X | |
| Habitat-related services | X | X | |
| Aesthetics of landscape | X | X | |
| Natural and cultural heritage | X | | |
| Education, Science | | X | |
| Water-related activities | X | | |
| Hydropower | | | |
| Navigation | | | |
| Sediments for construction | X | | |
| Ecological status | X | | |

Some of these services could not be assessed, although being of relevance, due to missing data. This includes all provisioning services ( Table 2, violet), flood risk mitigation (Regulation & Maintenance services, Table 2, green) and natural and cultural heritage as well as water related activities (cultural services, Table 2, blue). Sediments for construction has been dismissed as not being relevant in the study side Kleblach-Lind. The ecological status as ecosystem service has not been assessed in this analysis, however, the ecological status, as defined in the water framework directive, is included as input variable in the ecosystem service aesthetics of landscape.

# 3 ES analysis

## 3.1 Drau River

The monitoring approach selected for the ES-Analysis corresponds to a Before-After design. The pre-restoration state in this assessment concludes data of the years 1990, 1991 and 2001, depending on the indicator calculated. For the assessment of the post-restoration state, data of 2018 (land use) and 2019 (cross section data) were used.
According to the identified ecosystem services, the availability of data and the possible indicators introduced in D.T1.3.1, a set of applicable indicators was selected (Table 3).

**Table 3 ES service with indicator and data foundation**

| Ecosystem Service | Indicator | Data |
|---|---|---|
| **Retention of nutrients** | Indicator from Burkhard et al., 2014 | CLC |
| **Reduction of greenhouse gas emission / carbon sequestration** | Carbon sequestration (ton/ha/y) | CLC IPCC |
| **Drought risk mitigation** | Water surface elevation change | CHEVO |
| **Regulating temperature/Cooling (water bodies and ground)** | Water surface width | CHEVO |
| **Habitat-related services** | Erosion and deposition in aquatic, terrestrial, semiterrestrial zone as provision of possible new habitats | HyMoLink |
| **Aesthetics of landscape** | Hermes et al., 2018 | LULC, orthophotos |
| **Education, Science** | DT1.3.1 | orthophotos |

Since the study area was not divided into subunits, normalisation of the indicators was obsolete.

*Retention of nutrients*

As an indicator for retention of nutrients, the method suggested by Burkard et al. (2014) was applied, as described in D.T1.3.1. It divides the examined area into segments of different land use, with each land use category having a nutrient retention potential assigned. The overall potential is derived by taking the arithmetic mean of the RN-potentials of the two CLC categories covering the biggest area and rounding up the result.

**Table 4 Value of the indicator for retention of nutrients**

| Year | Indicator |
|---|---|
| 1991 | 1 |
| 2018 | 2 |

It may be difficult to evaluate the quality of this indicator, since the main input data, the Corine land cover maps, changes over time not just based on actual land use. In some years, some areas are divided into smaller areas with different properties, which complicates the comparability of the method described above.

*Drought risk mitigation*

To indicate an effect of channel widening on drought risk mitigation, the groundwater table depth was determined by calculating the difference between the water surface elevation and the floodplain elevation, assuming that the groundwater table correlates with the water surface elevation and that the drought risk depends on the groundwater level depth below the floodplain. Table 5 shows higher water levels in 2019 compared to 1991 in all four cross-sections examined. The water levels were modelled using the newly developed tool 'Chevo'.

**Table 5. Change in groundwater table depth**

| | 1991 | 2019 | 1991 | 2019 | 1991 | 2019 |
|---|---|---|---|---|---|---|
| cross section | water level elevation [m a.s.l.] | | mean floodplain elevation [m a.s.l.] | | groundwater table depth [m] | |
| 583.121 | 568.562 | 568.911 | 572.495 | 572.381 | 3.933 | 3.470 |
| 582.683 | 568.008 | 568.830 | 571.815 | 571.634 | 3.807 | 2.804 |
| 582.295 | 567.806 | 568.273 | 571.038 | 570.986 | 3.232 | 2.712 |
| 582.092 | 567.177 | 567.767 | 571.097 | 571.031 | 3.920 | 3.263 |

As indicator value the mean groundwater level depths for the channelised (1991) and restored state (2019) were calculated (Table 6). Changes in more then 3 m depth may be very relevant for drought risk, as the thickness of fine sediment on top of the gravel layer was determined at a riverbank to be around 3.5 m (Klösch et al., 2015), so that the difference between the two levels may decide whether the groundwater reaches the fine sediment and whether a capillary rise of groundwater into the fine sediment may occur during low flow condition.

**Table 6 Mean groundwater table depth as indicator for drought risk mitigation**

| mean groundwater table depth [m] | |
|---|---|
| 1991 | 3.723 |
| 2019 | 3.062 |

*Regulating temperature/Cooling (water bodies and ground)*

As an indicator for the temperature regulating effect of the water body, the mean water surface width, as calculated with the tool CHEVO, was selected.

Channel widening caused an increase in the mean channel width of 17 m (Table 7), which therefore suggests a better cooling/ temperature regulating effect in the post-restoration state.

**Table 7 Values of the indicator for Regulating temperature/Cooling**

| Year | Indicator |
|---|---|
| 1991 | 41.3 |
| 2018 | 58.3 |

*Habitat-related services*

For the habitat related service, the newly developed tool HyMoLink was used. HyMoLink compares two states of cross-sections and evaluates aggradation and degradation in zones relevant as physical habitats. Morphodynamics are important especially for the rejuvenation of riverine species (loose gravel for spawning, bare bars for pioneer vegetation, steep banks in cohesive sediment for bank-nesting birds, etc.). Due to availability of data, only four cross-sections were examined in the period 1991 – 2001, while from 2018 – 2019 17 cross-sections were extracted from digital elevation models for examination. As indicator value, the sum of the average cross section length showing erosion and deposition in individual zones (aquatic, semiterrestrial, and terrestrial) is calculated (Table 8).

**Table 8 Values of the indicator for habitat-related services. The values represent average cross section lengths showing the corresponding morphodynamic process.**

| | 1991-2001 | 2018-2019 |
|---|---|---|
| Aggradation in aquatic zone (m) | 11.54 | 33.53 |
| Erosion in aquatic zone (m) | 9.22 | 13.33 |
| Aggradation in semiterrestrial zone (m) | 0.41 | 3.39 |
| Erosion in semiterrestrial zone (m) | 1.98 | 1.02 |
| Deep erosion of cohesive banks in terrestrial zone (m) | 2.36 | 1.02 |
| Sum (m) = Indicator for HS | **25.51** | **52.29** |

The morphodynamics in the period 2018-2019 were increased due to the effects of restoration, but also included the effects of a 10-year flood, which occurred in October 2018.

*Aesthetics of landscape*

To indicate the aesthetics of landscape, the approach by Hermes at al. (2018) was adapted and used. This method includes the number of different land uses in this area, the ecological status and the morphology (as percentage of area with rare morphology to total area). Here, the ecological status (normalized; very good =1, good=0.8, etc.) substitutes the Shannon diversity Index, which was originally proposed by Hermes. The final indicator is derived by weighting each component and summing them up, with the weights being 0.25 for the ecological status and for the number of patches and 0.5 for morphology.

**Table 9. Values of the indicator for aesthetics of landscape**

| Year | Ecologic Status | Patches | Morphology | Indicator |
|---|---|---|---|---|
| **1991** | 0.6 | 6 | 0 | 1.65 |
| **2018** | 0.8 | 9 | 10.4 | 7.65 |

*Education, Science*

As described in D.T1.3.1, this service has been assessed by calculating the proportion of the area that is a priority site and/or a rare morphology. The two resulting relative values were weighted (0.5) and summed up. The added value in morphology and habitats created shown in Table 10 is only a rough approximation, since this indicator is derived just from orthophotos.

**Table 10. Value of the indicator for Education and Science**

| Year | Morphology | | | habitats | | EDS |
|---|---|---|---|---|---|---|
| | total area | area [m²] | relative [%] | area [m²] | relative [%] | |
| **1991** | 1721070 | 0 | 0 | 0 | 0 | 0 |
| **2018** | 1721070 | 179055 | 10.4 | 179055 | 10.4 | 10.4 |

*Summary of ES scores*

Table 11 summarizes the indicators listed above, demonstrating positive effects of the restoration measure on all the ecosystem services examined in this analysis:

**Table 11. Summary of the scores for the ES**

| Year | RN | DM | RT | HS | AES | EDS |
|---|---|---|---|---|---|---|
| **1991** | 1 | 3.723 | 41.3 | 25.51 | 1.65 | 0 |
| **2018** | 2 | 3.062 | 58.3 | 52.29 | 7.65 | 0.33 |

# 4 Conclusions and perspectives

## 4.1 Drau River

The analysis suggests an overall positive development of the examined ecosystem services after the restoration measure. However, concerning the assessment of these indicators, experience shows that the availability of data tends to have a huge impact on the choice of indicators and therefore on the results obtained.

Overall, high resolution data (both spatial and temporal) like the used cross-section data is not available for applying some of the indicators, hence the availability is a limiting factor.

# 5 References

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