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Alpine SPACE
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SEDALP

SedAlp project: Final Conference and results

Dear Readers, Dear Colleagues, Dear Friends!

Investigating the short, medium and long term requirements for the improvement of sediment continuity in our Alpine basins – these were the objectives that framed us in the last three years, during the implementation of the European Territorial Cooperation project "**SedAlp**" within the Alpine Space Programme.

Sediment and woody debris management in Alpine basins is a very complex and cross-cutting issue for our environment, ecology, hydropower production, flood control or river morphology. Providing answers, tools, and recommendations in order to balance multiple-demands in sediment management were the vision underlying the SedAlp project, and its findings were presented in Bolzano (Italy) during the International Final Conference on 9th-10th June 2015. The event was organized by the Autonomous Province of Bolzano and the University of Bolzano.

Further to the 14 project partners from ministries, local authorities, universities, and research institutes in the Alpine countries, several other interested parties from administrative, scientific and practical fields were present to share in this concluding event. The agenda featured keynotes, technical presentations and panel discussions with representatives of national and regional coordinators and decision-makers. The discussion allowed highlighting the policy & practice-relevant characteristics of the SedAlp Project specifically, as its aims and works addressed an emerging field. The overall tenor was: the geological and climatic variability across the Alps generate complex patterns of sediment transfer, whereas management conflicts are similar. This calls for common action: elaborating and promoting transnational solutions for transnational problems is more effective than solely national/ regional strategies.

That has been fully and impressive proved by the SedAlp partnership!

The Synthesis Report and deeper insights on the overall project results, methodology and tools/instruments set up for its purposes can be found on our project website: www.sedalp.eu

Yours sincerely,

Maria Patek
Legal Responsible SedAlp Project- BMLFUW Austrian Federal Ministry for Agriculture, Forestry, Environment and Water Management - Head of Dep. IV/5 - Torrent and Avalanche Control

Project partners representatives at SedAlp final conference in Bolzano (Italy), 9th June 2015.

Workpackage 4 (WP4): key findings and recommendations

Activities that took place in WP4 ("Basin-scale sediment dynamics") during the last three years come out with a significant step-forward in sediment source mapping for a variety of Alpine environments. A comprehensive analysis of the sediment cascade in Alpine river basins should start by the detection and characterization of sediment sources. Several original methods were implemented during the project to capture the spatial and/or temporal variability of sediment sources, at local and regional scales. Several illustrative sediment source maps of large and small alpine basins (from around 10 to 1000 km²) were provided and give to practitioners some examples of products that can be achieved using the different approaches exploited by the project partners.

New high-resolution observations of erosion rates from active sediment production zones of the Alpine Space have been also provided. Change detection from sequential terrestrial or airborne LiDAR data was implemented in several active sediment production zones of the Alpine Space to provide new data on time-integrated erosion rates of hillslopes feeding stream channels with sediment. Several case studies of the project illustrate how these data can be processed to isolate geomorphic changes from noise, to characterize the spatial variability of uncertainty for change detection, and to provide a sound catchment-scale sediment budget.

Another key output from WP4 is the development and test of two original GIS tools dedicated to sediment connectivity assessment (SedInConnect) and fluvial corridor analysis (FluvialCorridor ArcGIS toolbox), already presented in previous newsletters of the SedAlp project and available on the website.

Exploration of the time dimension of the sediment cascade gave some new insights into the historical analysis of Alpine basins. Some examples of such approach are provided in the project, for reconstructing the time evolution of channel incision subsequent to catchment reforestation, or for looking at the effect of glacial imprints on source-to-sink colluvial pathways in a formerly glaciated setting.

Finally, a list of recommendations for policy makers and practitioners was provided, as for example the promotion of a basin-scale approach of sediment management issues. This is needed for understanding the geomorphic evolution of a river channel (e.g. aggradation/degradation) through geomorphological mapping and analysis of historical maps and aerial photos, and proposing reliable solutions for both natural hazard and environmental management.

It is also proposed to support the collection of high-resolution LiDAR surveys of Alpine catchments, and make data available at no or low cost. A first priority is to achieve complete area coverage in order to enable mapping of sediment sources, connectivity assessment, and modeling of sediment transfer. A second priority is to establish regular repeated surveys (e.g. every 3-5 years); multitemporal surveys are indispensable tools for change detection and quantification, and finally for prioritization of management decisions.

The establishment and management of accessible archives of historical aerial photographs in digital form are also recommended. WP4 activities provide numerous examples of how these data can be used for reconstructing the long-term evolution of catchments, representing strategic material for the interpretation of present-day observations and for supporting management decisions.

Figure 1 - Strimm Torrent catchment (Venosta Valley, Italy).

The promotion of research on sediment continuity in Alpine basins is also important. It is recommended to maintain a substantial level of scientific investment in this field, notably by promoting collaborations between river ecologists and specialists of sediment transport and river morphology.

All the WP4 results were synthesized in a report called: "Guidelines for assessing sediment dynamics in alpine basins and channel reaches". This report was completed by a compilation of 10 case studies with more specific information about methodological developments and results; reports can be downloaded on the SedAlp website.

Workpackage 5 (WP5): results and outputs

Within the SedAlp workpackage 5 ("Sediment transport monitoring"), monitoring activities and analyses on 34 different pilot sites in Austria, Germany, France, Italy and Slovenia have been conducted. The monitored transport processes covered woody debris, debris flow, bedload and suspended load. The different pilot sites showed a great diversity in catchment size, channel slope and hydraulic parameters and covered small, high alpine catchments (e.g. Strimm: 5 km² catchment size, 2427 m elevation a.s.l.) to large catchments in the Alpine valleys (e.g. Drau/Dellach: 2131 km² catchment size, 600 m elevation a.s.l). Based on the results of the monitoring activities, databases with monitoring results of all observed transport processes have been established. These databases represent a major output of the first coordinated sediment and wood transport monitoring in the Alpine region. An additional highlight was the development of an automatic wood transport detection system based on video imagery.

Due to the wide range of different measurement methods used within the project, one focus of this workpackage was a standardization of measurement procedures and harmonization of data analysis. This task led to the 1st milestone "Protocol on standardized data collection methods in sediment transport monitoring for transboundary exchange". These protocols describe the used monitoring techniques and data processing methods for debris flows, wood transport and bedload transport and highlight the suitability in the application of these methods. Furthermore, the protocols work also as guidelines to assist in choosing the appropriate monitoring method for supporting prospective monitoring efforts. Overall, a combination between direct and indirect suspended, bedload, debris-flow and wood monitoring techniques is recommended to gain representative field data.

An important aspect of the project was a better understanding of the spatial and temporal variability of the monitored processes. Within the project period, intensive clockwise and counter clockwise hysteresis effects between sediment transport and discharge have been observed, showing the significant role of the location of the active sediment source in the temporal variability of sediment transport. Analysis of the spatial distribution revealed an evolvement of the bedload transport width with increasing discharge which provides vital information for an improved planning of river related measures.

The presented data reflect a high spatial and temporal variability in the occurrence of bedload, suspended load debris flow and wood transport and reveal significant consequences for the practical usage of monitoring methods, data and application.

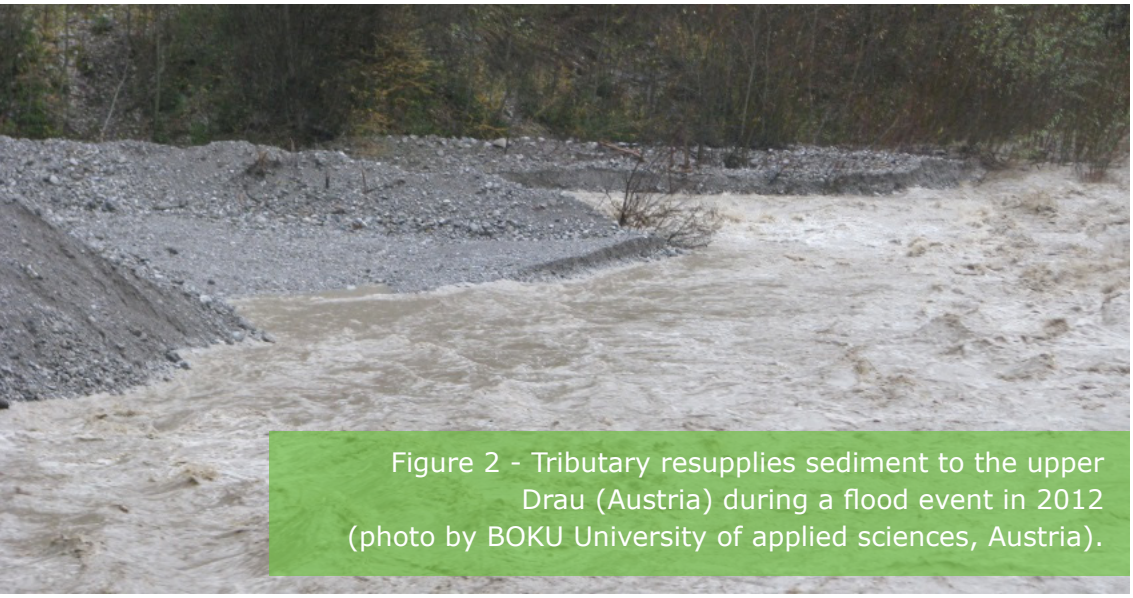

Figure 2 - Tributary resupplies sediment to the upper Drau (Austria) during a flood event in 2012 (photo by BOKU University of applied sciences, Austria).

Many river engineering tasks require detailed information about the extent of sediment transport and wood mobility, which are often provided by sediment and wood transport relations and equations. The 3rd Milestone "First set of practically applicable bedload/wood transport relations and models" gives an overview about the most common transport relations and formulas for bedload and wood transport. It presents the difficulties and challenges in the application of these relations and shows the last developments in improving transport equations. Furthermore, a software tool for hydraulic and bedload transport computation has been developed, featuring three widely used bedload transport equations.

The analyses of river restoration projects reflected the need of an improved process understanding between sediment transport and engineering measures. The results show, that the functionality and sustainability of river restoration measures are, beside the hydrologic and hydraulic conditions, mainly depending on the superior sediment regime and thus the sediment input into the reach.

The coordinated sediment transport monitoring performed in this project, outlines the links between the various processes responsible for sediment delivery at catchment scale. This stresses out the need for a closer integration between the monitoring of various sediment transport processes in Alpine headwaters. All reports, milestones and outcomes are available for download on the SedAlp website: http://www.sedalp.eu/download/reports.shtml

Final Conference in Bolzano and Venosta Valley (Italy)

The Final Conference of the SedAlp project took place at University of Bolzano/Bozen on 9th June 2015. In this first day, the project and its main results were presented and experts focused with keynote-speeches on relevant sediment management issues in the Alpine basins. Interesting interactive discussions about project results and sediments related issues were alternated during presentations. Meanwhile a poster session gave the opportunity to discuss and to increase knowdledge about the topics and different study areas of the project.

Figure 3 - Discussion during the Final Conference of SedAlp project, University of Bolzano/Bozen (Italy), 9th June 2015.

On 10th June, the second day of the event, a very interesting field trip was organized to the Gadria creek debris flow monitoring station and to AQUASED Solda River bedload monitoring station (Venosta Valley, Italy).

The whole event attracted considerable attention and participation. These two days were intense and full of ideas and discussions, which managed to involve all the numerous stakeholders interested in the matters dealt and present at the event. More detailed insights of the event, such as presentations, photos and flyer are available on the SedAlp website: www.sedalp.eu

Figure 4 - Project partners representatives and participants to the technical trip at Gadria creek debris flow monitoring station in Venosta Valley (Italy), 10th June 2015.

Figure 5 - Presentation of AQUASED Solda River bedload monitoring station (Venosta Valley, Italy) during the field trip of the Final Conference, 10th June 2015.

Workpackage 6 (WP6): main recommendations and results

WP6 research ("Interactions with structures") was dealing with manmade structures in river systems and torrents which have various impacts on sediment transport process. Research was focused on how to plan and design efficient structures with low impact on sediment continuity. Research included torrent control structures, flood protection systems, river restoration projects and HP dams. Basing on research which included state of the art overview, field survey, numerical modeling and physical scale modeling, one Report on improved concepts and three Guidelines were provided and are now available on SedAlp website:

- Improved concepts of responses of torrent/river control structures to floods and debris flow impacts (including wood).
- Guidelines for planning/designing of efficient torrent control structures with low impact on sediment continuity between upstream torrential headwaters and downstream river reaches.
- Guidelines for improved planning of hydropower plants aimed to improve the longitudinal sediment continuity between upstream torrential headwaters and downstream river reaches.
- Guidelines for planning and designing of effective flood protection systems, river training and restoration projects that have lower impact on sediment continuity.

Report and guidelines include recommendations for Policy makers, Practitioners and for Researchers. All the recommendations are included in the reports, but we would like to point out the following ones.

Recommendations for Policy Makers

- Adequate risk-based land use planning;
- Holistic (whole river system) approach when planning flood protection and control measures;
- Awareness of vulnerability of control structures for events with longer return period than the designed one – evacuation plans, risk management, additional measures;
- When planning structures, measures and hydropower structures, morphological point of view must also be taken into account, not only hydrological/hydraulic and ecological point of view;
- Environmental impact assessment should precisely determine the magnitude of disturbance and lead to a detailed prescription of compensation measures.

Recommendations for Practitioners

- Prevailing extreme sediment transport process should be identified for each reach of the torrent (floods, fluvial solid transport, debris flood and debris flow);
- Functions of torrential barriers can be divided in the following functional types in view of processes: stabilization/consolidation, retention, dosing and filtering, energy dissipation;
- Torrent control measures should be scenario-oriented;
- Practitioners should be open to consider deriving knowledge for the planning process from backward-oriented indication, mathematical modelling and physical lab experiments.

Recommendations for Researchers

- Long-term data collection, analysis and survey of sediment retention basins – also surveying during filling and self-cleaning (self-cleaning optimization) and after disaster (focus on sediments and driftwoods);
- Further development of sediment connectivity management implementation guidelines;
- Applied research targeted at improving the quality of protection system design;

- Specific research to better understand river morphology, eco-hydraulic processes, system functions and the related, monetarily quantified system services.

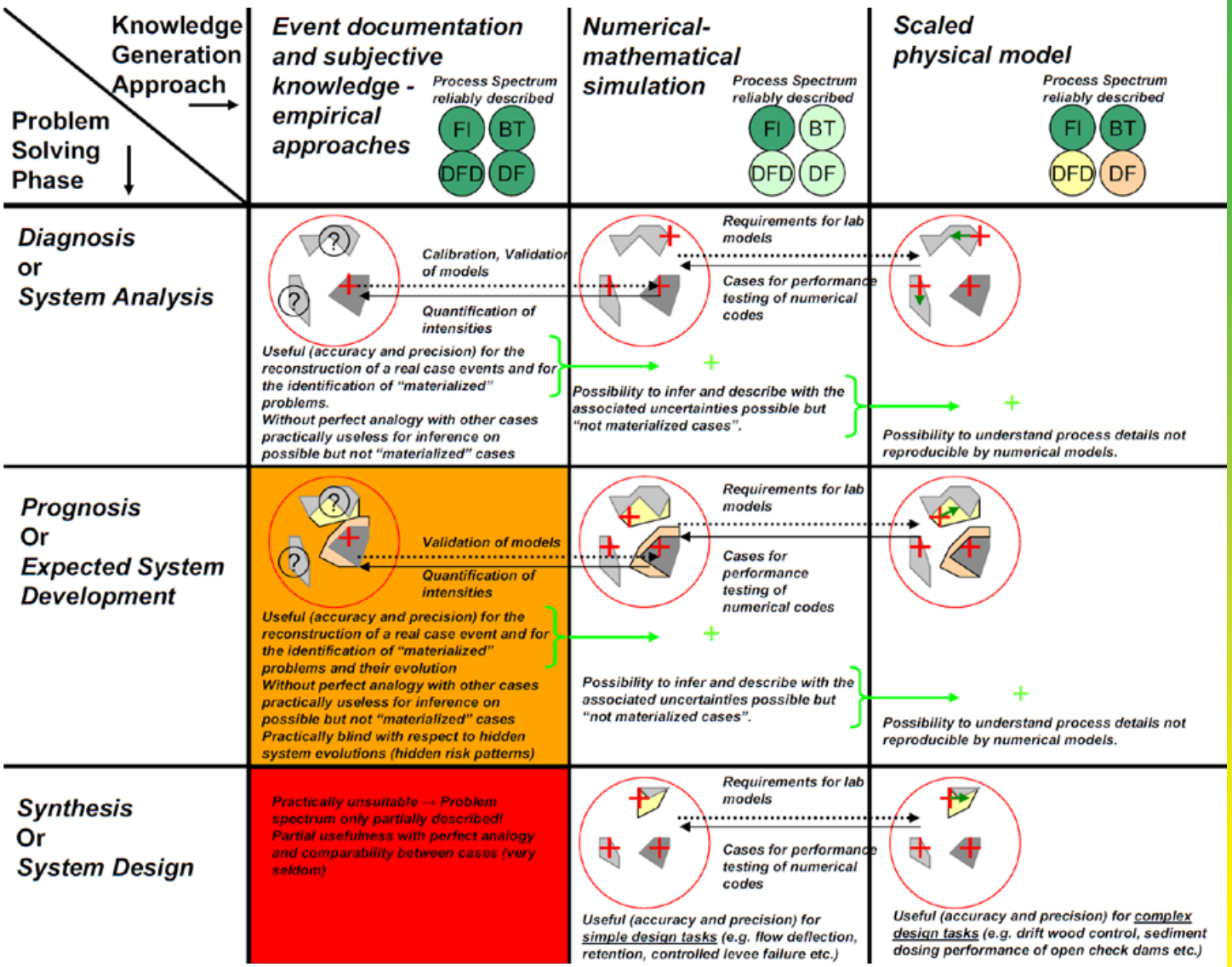

Figure 7 - Proposed knowledge management navigator throughout the core design process of an efficient torrent control structure.

SedAlp insights: Slovenian torrent and erosion control & disseminating SedAlp results

By the end of June 2015, two protective object type wooden cribwall will be built in the hinterland areas of the test bed of torrent Bistričica (Slovenia): one cross-sectional facility (check dam) and one longitudinal building (support of landslide near the torrent). The implementation of the project is financed by the Slovene Fund "Si.voda" (donation), the municipality of Kamnik (SedAlp's official observer) and the Slovene Ministry of Environment and Spatial Planning - Environmental Agency. The project is from the beginning supported by SedAlp partner Inštituit za vode Republike Slovenije and its external expert support "Hidrotehnik", both in terms of design and for the final presentations made. Given that it is near the site very popular starting point for hikers, tourists, school trips, intensive dissemination activities were included in the project, with an intention to informing and raising awareness among the interested visitors about the natural processes and methods of water& erosion risk management in Slovenia. In the parking lot for visitors and in the immediate vicinity of constructed structures will be permanently placed two information boards, which will describe the results of the project SedAlp.

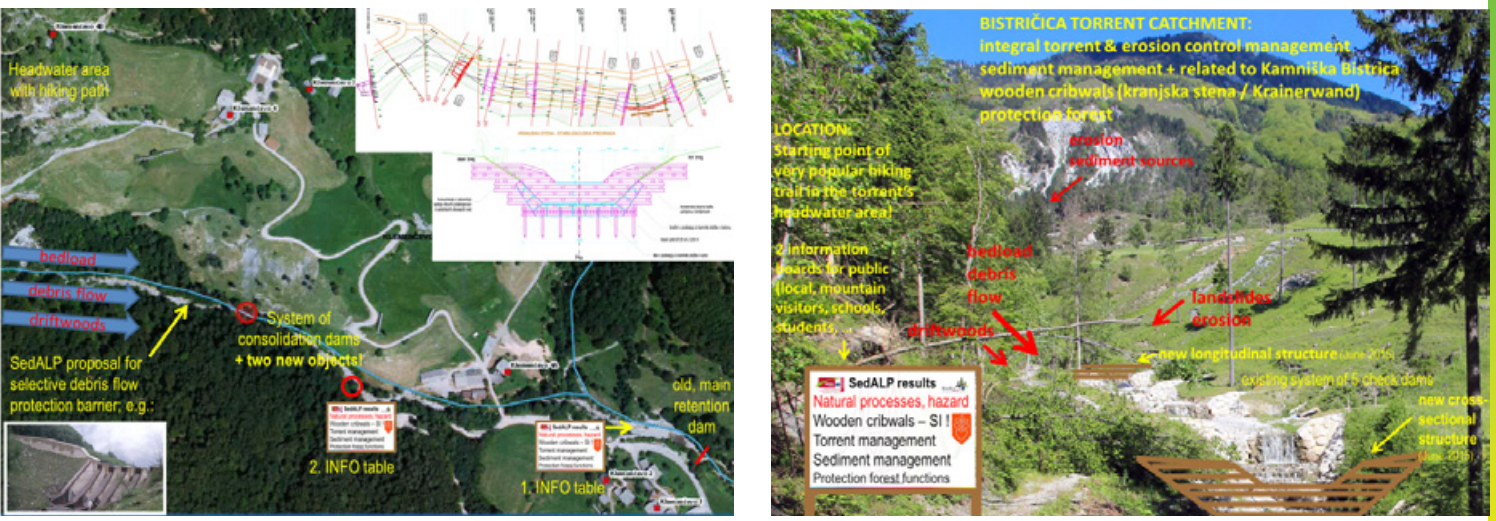

Figure 8 - 9 - Location of preventive protective measures and SedAlp's information panels = Environmental-sound structural protection measures for benefits of local inhabitants and visitors (protection of local infrastructure).

The main communication objectives are: raising awareness of general public and local/regional stakeholders for the importance of integral torrent / sediment management; informing about the added value of transnational cooperation in the field of water, sediment and natural hazard risk management (results of SedAlp partnership): informing and training of esp. young water/torrent experts. Target groups are: local, regional, national stakeholders (e.g. politicians), ministries, government, general public, experts, NGOs, media (print, radio, tv), authorities, administration, other projects and programmes & the EU, schools, university etc.

Wooden cribwalls (Kranjskastena in Slovene, Krainerwand in German) are very old technique used mainly for protecting slopes against surface erosion and rivers against river erosion and are the symbol of traditional river and torrent engineering in Slovenia, representing technical and cultural heritage (included in Register of Intangible Cultural Heritage in 2013). Nowadays there is evident increase of wooden cribwalls construction, also due to the fact, that river engineering works has to be harmonised with environmental needs, landscape planning and socio-economical demands. Technique in general stays the same through the time - particular stages of construction are improved or simplified, what represent higher applicability of wooden cribwall on the terrain.

Figure 10 - 11 - Left: Wooden Cribwall on Pšatariver and right: building of wooden cribwall on Bistričica (13.06.2015).

Wood, stone, especially the one obtained from the torrent beds, and the combination of the two, are preferred materials not only from aesthetical, but also from the functional and rationality point of view. Wooden cribwall is recognized as Slovenian river engineering good practice, due to the fact that is has good hydro technical characteristics (resistance to shear stress during flood events, resistance over time, enable percolation, adaptable to terrain characteristics etc.), high coincidence with landscape (in mountainous / hilly region), low negative impact on environment (in case of vegetated wooden cribwall with autochthon plants, adapted to natural channel characteristics and bank slope, enabling lateral connectivity between channel and riparian zone etc.) and high socio-economical value (improving the value of human environment, strengthening of region characteristics by using local materials, compatibility with recreational and tourism activities, representing cultural and technical heritage, acceptable cost of construction and maintenance).

Slovenia faces different forms of erosion, among which water erosion is particularly significant. The most significant are torrent outbursts, extreme sediment transport and debris flow events, landslides, rockfall and avalanches. 44 % of the area is potentially at risk by erosion, one third of the area is considered as unstable or conditionally stable. Almost one quarter of Slovene territory are torrential watersheds, where the erosion phenomenon can obtain larger dimension and cause major damage when precipitations are intensive. Integrated water management begins in torrent catchments. Bedload transport control is successfully carried out by correctly positioned and designed consolidation and retention structures. These structures are generally integrated in a system and therefore their functions are interactively supplementing. Since the beginning of the organized torrent control in Slovenia in 1884 (1875), quite a lot of work has been done, and safety from erosion and torrents has been substantially improved.

The torrent control management still faces numerous tasks, in spite of the extensive control and management work conducted in the past. In the control and management of torrent and erosion areas we should always be aware that we are managing them in a complex way, taking into account, technical, biotechnical, agro technical and legislative measures. Especially technical antierosion measures are those, which could have negative environmental impacts. We should use them very selectively on the areas, where erosion processes are concentrated or where they are progressively advancing. Environmentally adequate cross-sectional structures consider visual (aesthetical) and functional aspects. The visual aspect is always associated with the functional one and at the same time subordinated to the former. Stone and wood are ecologically sounder materials (e.g. wooden cribwalls). Increased number of weather extremes are causing increasing number, frequency and intensity of natural disasters, and because of the economic development, the consecutive damages are getting proportionally bigger. The significance of maintenance and modernization of the existent torrent control structures is therefore getting larger. Only well maintained torrent control structures and systems can perform the required function.

We have to pay more attention to systematic measuring and analysing of magnitude and frequency of sediment transporting events in Slovene torrents. Because of the obvious non-maintenance of the larger number of torrent structures, Slovenia will have to assign a larger share of funds to their maintenance and increase the share of funds for prevention measures afterwards, to preserve the balance conditions in torrential catchments. Weather extremes could become even more frequent, and the time for catching up the earlier lack of maintenance measures is running out. SedAlp results and outputs are recognised as significant expert contribution in the right time, to improve sediment management such on catchment's level as on larger scale – on river basins level – to achieve the goals and synergies of EU "Water" as "Flood" Directive.

Workpackage (WP7): guidelines and recommendations

WP7 ("Sediment management -including large wood") focused on the integration of methodological approaches across scales and provides guidelines for policy development in the context of sediment and large wood management.

Two guidelines with methodological explanations and good practice examples were provided into the SedAlp Project. The contents of the first guideline are the estimation of sediment budget and scenarios determination to be used for flood mitigation in Alpine basins. The identification of morphological impacts related to hydropower plants and gravel extraction is dealt within the second guideline. Different key findings were obtained during the project, the main aspects related to the guidelines are presented below.

Guideline 1: Estimation of sediment budget, including large wood monitoring and scenarios determination to be used for flood mitigation in Alpine basins

- *River Scaling Concept – Morphodynamics Evaluation Tool:* The application of the River Scaling Concept – Morphodynamics Evaluation Tool (RSC-MET) for reach evaluation follows a three-step process. 1) Evaluation of the connectivity of the reach to sediment production in its catchment; 2) Analysis of the sediment transferred through the river network to the downstream reach; 3) Investigation of the reach for its own sediment budget and for its artificiality.

- *A GIS-based planning system for targeting sediment management at hydrographic district scale*: A GIS methodological framework was developed to support spatial analysis of stream networks based on disaggregation and aggregation procedures of geographical objects derived from remote sensing data. A spatial database of elementary attributes was generated by continuously measuring the stream network at the scale of high resolution spatial units derived from spatial disaggregation of basic geographical objects.

- *Effective discharge for bedload and for suspended load*: Morphodynamic investigations dealing with sediment transport are often focused on the long-term stability of river channels. The representative discharge used for these studies is called channel forming discharge Qcf. To quantify the channel forming discharge Qcf the evaluation of the effective discharge Qeff, defined as the discharge that transports most of the sediment, represent a useful parameter for investigations concerning channel design.
- *Large wood storage, distribution and driftwood hazard at bridge structure*: A GIS-based conceptual model designed and calibrated in order to reproduce LW input and its transfer along the fluvial network was developed. The GIS-based conceptual model can be applied by using a specific cell-size resolution, and it is formed by three sub-models: (i) Instability sub-model, (ii) Hillslope transfer sub-model, and (iii) River transfer sub-model.

Guideline 2: Identification of morphological impacts related to hydropower plants and gravel extraction

- *Short term channel adjustment and geomorphic change detection for assessment of both floods impacts and gravel extraction*: To quantify short term channel adjustment and geomorphic change, related with floods and gravel extractions, two consecutive LiDAR and aerial photos surveys have to be committed before and after a relevant flood. A precise DEMs of difference (DoD) can be carried out in order to quantify the morphological changes occurred.

- *Implementation of Multicriteria Analysis in a selected HP basin (Pramper stream, Belluno Province)*: To integrate and complete a Reservoir Management Project with the mechanical removal of coarse sediments stored in the reservoir and its input into the downstream channel reach. The effects of such an operation on the river system (energy production, environment, morphology, social aspects) can be evaluated with a Multicriteria Analysis (MCA). The MCA logical steps are: evaluation matrix; utility functions assignment to each indicator; weights assignment; alternatives ranking.

WP7 General Conclusions and Recommendations

The geologic and hydrologic settings of hydropower plants-reservoir vary widely, and thus no one approach is suitable for all sites. Quantification of upstream sediment yield to the reservoir-hydropower plant, with projection of reservoir sedimentation rates into the future as well as management based on more sustainable principles are needed. Long-term and large scale perspectives of the stream network must to be considered in the sediment management. In order to better define the availability of transportable sediment and large wood, it must be taken into account both basin and channel characteristics and processes as to be able to define the most appropriate approaches and tools to estimate sediment and wood budgets. For an efficient structure design, appear mandatory the analysis and consideration of different scenarios based on the existent sediment continuity, torrent control strategies and control structures characteristics. The main aim of the sediment management strategies must become the decrease of negative impacts, on riverine environments, related to hydropower plants and gravel mining activities. The identification of problems and methods of solutions should be addressed through the collaboration of policy makers, practitioners and researchers.

Recommendations for Policy Makers

The policy makers have the fundamental role to promote data sharing and experience with common informatics databases for more robust evaluations of sediment and wood budgets. There is a need to bring law and science closer together in terms of reality and processes.

Recommendations for Practitioners

Practitioners should be aware that a knowledge of hydrological regime of the entire basin, geological settings, lithology and the macro and micro fauna types are fundamental to better define the reservoir maintenance and management. The availability of long-term, accurate hydrologic and sediment data are essential for the purpose of operation and management.

Recommendations for Researchers

An integrated collaboration between different scientific disciplines is fundamental to improve the knowledge on sediment management. An integrated and more precise estimation of sediment and wood budget at different spatial and temporal scales is needed, such as a more thoroughly analysis of the interaction between sediment-wood and transversal structures.

For Synthesis Report, WP-final reports of SedAlp project and details of the project and partnership please visit the SedAlp website www.sedalp.eu and the page!

Contacts:

- SedAlp Lead Partner: BMLFUW (Austria)
  andreas.pichler@lebensministerium.at
- SedAlp Communication: Regione Piemonte (Italy)
  info@sedalp.eu

www.sedalp.eu

Project partners

Austria

- Bundesministerium für Land und Forstwirtschaft, Umwelt und Wasserwirtschaft (Lead partner)
- Amt der Tiroler Landesregierung
- Amt der Kärntner Landesregierung
- Universität für Bodenkultur Wien (BOKU)

France

- Centre National de la Recherche Scientifique (CNRS)
- Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture (Irstea)

Germany

- Bayerisches Landesamt für Umwelt (LfU)

Italy

- Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto
- Consiglio Nazionale delle Ricerche (CNR – IRPI)
- Provincia Autonoma di Bolzano/Autonome Provinz Bozen
- Regione Piemonte
- Università di Padova

Slovenia

- Inštituit za vode Republike Slovenije
- Univerza v Ljubljani

Project observers

- Agence de l'Eau Rhône-Méditerranée-Corse
- Agenzia Regionale per la Protezione dell'Ambiente della Valle d'Aosta
- Austrian Hydro Power
- Autorità di bacino del fiume Po
- Autorità di bacino del fiume Adige
- Bundesamt für Umwelt (BAFU)
- Enel Produzione SpA
- Enel Produzione SpA – UBI Hydro Piemonte
- Enel Green Power SpA
- Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (WSL)
- Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA)
- Maira SpA
- Municipality of Kamnik
- Regione Autonoma Friuli Venezia Giulia
- Regione Lombardia
- Regione Veneto
- Ricerca sul Sistema Energetico
- SEL AG/SpA
- Stand Montafon
- Verbund - Austria Hydro Power
- Vorarlberger Ilwerke AG

SedAlp – **Sed**iment management in **Alp**ine basins:
integrating sediment continuum, risk mitigation and hydropower

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