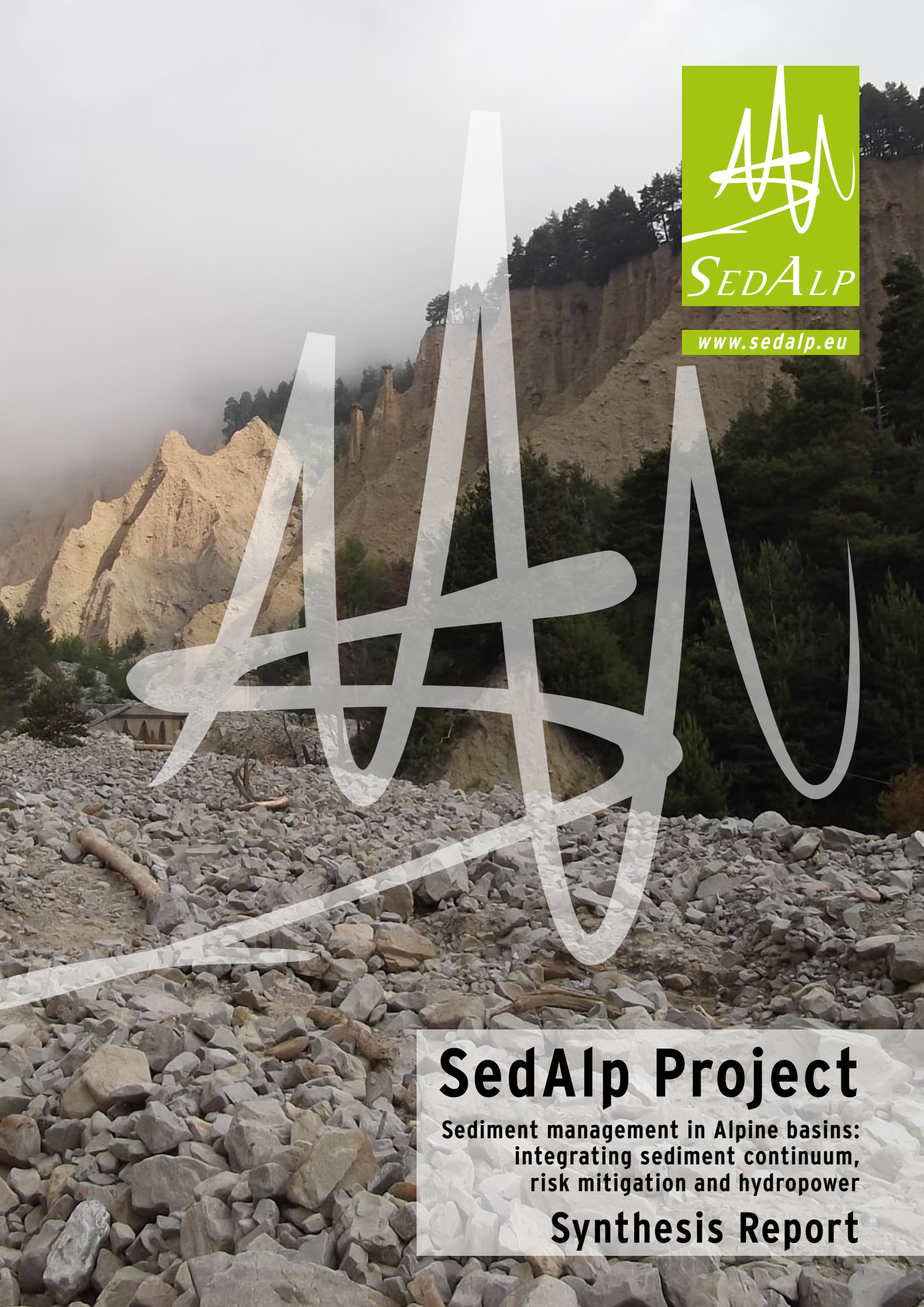

SedAlp

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SedAlp Project

Sediment management in Alpine basins: integrating sediment continuum, risk mitigation and hydropower

Synthesis Report

Disclaimer

Synthesis report of the project SedAlp - Sediment management in Alpine basins: integrating sediment continuum, risk mitigation and hydropower

The Synthesis Report is intended to provide relevant information and stimulate discussion between those with an interest in sediment and woody debris management. The results and conclusions of all single activities produced under the SedAlp project are available to governments at all levels, administrations, universities, industries, practitioners, and the public by way of the SedAlp website (http://www.sedalp.eu/).

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Executive Summary

This report aims at synthesizing results and recommendations from the activities of the SedAlp project. It provides an overview of the methods and approaches that were developed and identifies the most important findings on the understanding and enhancing of sediment continuity in Alpine rivers that are also helpful for the implementation of a couple of EU Directives, like the Floods Directive, the RES Directive, and the Water Framework Directive.

Practitioners and decision-makers can find research-based recommendations for improving sediment and woody debris management. They can take this document as a starting point to effectively search for further relevant outcomes of the SedAlp project.

The final reports of the four thematic SedAlp work packages as well as further deliverables are accessible via the SedAlp website: http://www.sedalp.eu/.

1 Introduction

1.1 Background of sediment and woody debris management in the Alps

In Alpine rivers, sediment transport processes are of great relevance due to their ecological, energy and risk-related consequences. In addition, sediment represents a highly valued raw material for constructions. Sediment fluxes, crucial to maintain a good ecological status of rivers (required by the EU WFD), provide the hydromorphological conditions supporting dynamic aquatic ecosystems. To achieve these, sediment continuity must be maintained or enhanced if already disrupted. Such goal is often in conflict with: (i) flood risk mitigation (Floods Directive) as sediment transport – often in conjunction with large wood – may strongly amplify flood hazards; and (ii) hydropower production (RES Directive), as it requires weir installations and reservoirs, which in turn cause technical, economical and ecological problems. Decision makers involved in river basin management in the Alps are thus facing the urgency to test policies able to reconcile these conflicting requirements.

1.2 Requirements for innovations in sediment and woody debris management

Sediment continuity has a notable impact on several management issues in alpine river basins and poses multiple use conflicts related to e.g. small hydropower, ecology, fishing, flood control, morphology, or the good status according to the EU Water Framework Directive. 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. Having in mind that sediment is an essential, integral and dynamic part of the river system the bundling of competencies and experiences of managers and experts from all over the Alpine Space will speed up and intensify the urgent required process of balancing multiple use conflicts related to sediment continuity in Alpine river basins.

1.3 Overall project objectives

In order to tackle these demands and challenges, 14 partners coming from Austria, France, Germany, Italy, and Slovenia agreed in 2012 to collaborate in a common project vision, by developing and testing strategic policies and tools for an integrated management of sediment transport in Alpine basins, directed to an effective reduction of sediment-related risk while promoting the enhancement of riverine ecosystems and reducing the impacts of hydropower plants. The overall project objectives can be summarized as follows:

- Highlight the need to explore basin-scale sediment dynamics
- Underpin the need for standardized monitoring, analysis and modelling methods and procedures in sediment and woody debris transport
- Investigate the interactions between existing and planned man-made structures and sediment dynamics including large wood
- Integrate methodological and management approaches across scales
- Show the practical implications by implementing piloting actions in various representative Alpine river basins of all involved countries
- Raise awareness of general public & local/regional stakeholders for the importance of sediment continuity
- Inform about the added-value of transnational cooperation in the field of water-, sediment- & natural hazard risk management

1.4 Description of the SedAlp partnership

The SedAlp partnership represented a strong vertically and horizontally integrated consortium of 14 partners coming from 5 countries across the Alps. This consortium was supported by 21 Observers. National, regional and local authorities and administrations responsible for sediment, water and woody debris management, practitioners, experts from the hydro-power sector as well as scientists formed the basis for cooperation, communication and exchange of knowledge and information which in fact resulted in notable results and outputs related to sediment and woody debris management in the Alps. In brief the following list refers to all SedAlp partners and observers:

Project partners

Austria Bundesministerium für Land und Forstwirtschaft, Umwelt und Wasserwirtschaft (Lead partner LP) • Amt der Tiroler Landesregierung (PP10) • Amt der Kärntner Landesregierung (PP13) • Universität für Bodenkultur Wien (PP11)

France Centre National de la Recherche Scientifique (PP8) • Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture (Irstea PP7)

Germany Bayerisches Landesamt für Umwelt (PP6)

Italy Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto (PP2) • Consiglio Nazionale delle Ricerche - IRPI (PP4) • Provincia Autonoma di Bolzano/Autonome Provinz Bozen (PP1) • Regione Piemonte (PP5) • Università di Padova (PP3)

Slovenia Inštituit za vode Republike Slovenije (PP12) • Univerza v Ljubljani (PP9)

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 • Enel Produzione SpA • Enel Produzione SpA – UBI Hydro Piemonte • Enel Green Power SpA • Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft • Illwerke AG • Istituto Superiore per la Protezione e la Ricerca Ambientale • 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 Illwerke AG

2 Executive WP overview

2.1 The thematic work packages in brief

The thematic work within the SedAlp project was structured along 4 main work packages (WP). These work packages were designed to better understand the complexity of sediment and woody debris continuity in the Alps, to explore what is meaningful and successful, and what can be improved in terms of promoting sustainable and integrative sediment management solutions. Beside these thematic-related work packages, four more work packages appeared in the project: two (WP1 and WP2) related to organizational/project management issues, WP3 focused on Information and Publicity, and WP8 had the objective to provide the synthesis.

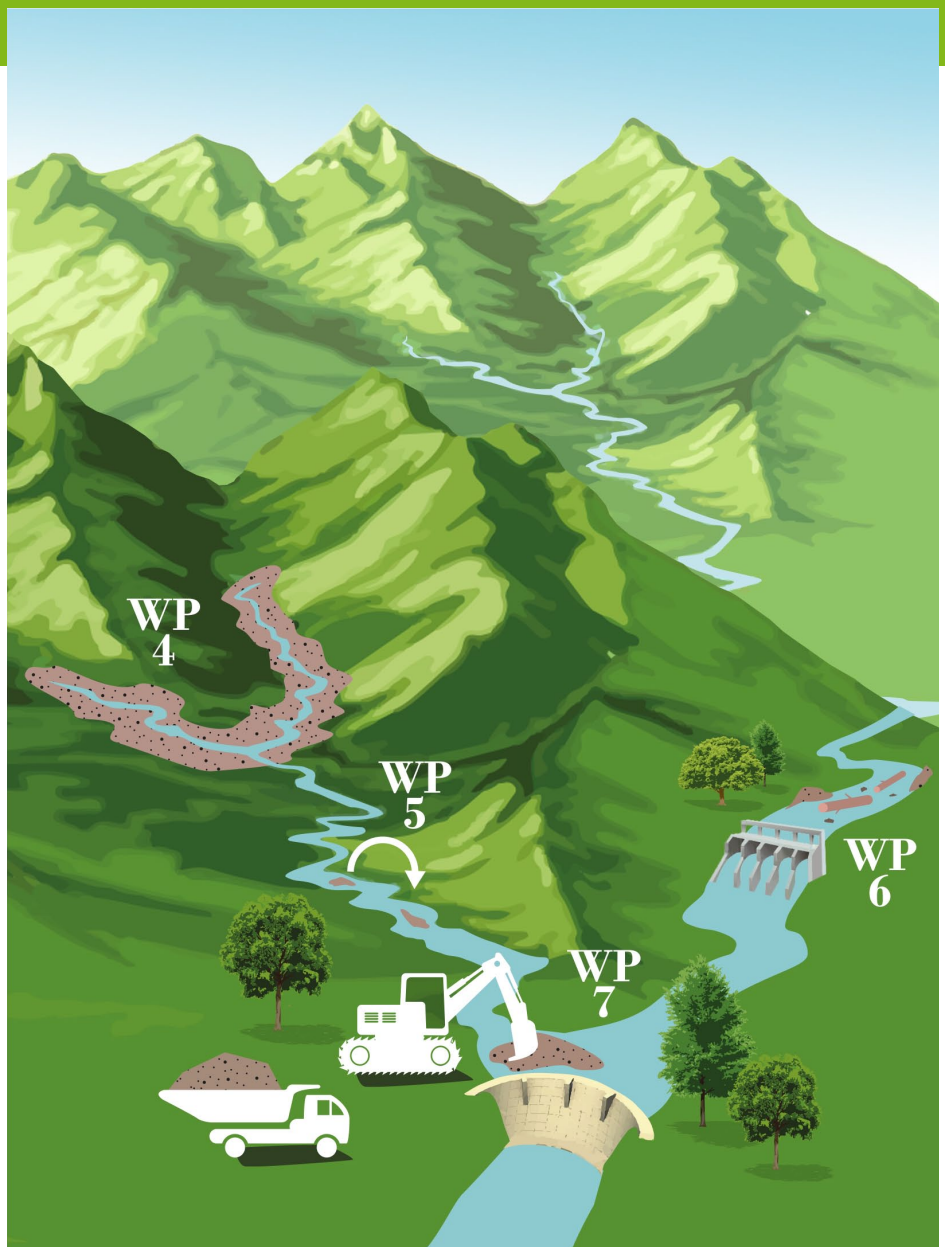
Table 1: SedAlp thematic Work package overview

Titles, main objectives, work package lead, contributing partners	Main activities
WP4: Basin-scale sediment dynamics Main objectives: • Analysis of the basin-scale sediment cascade • Characterisation of sediment sources, storage sites, and transfer rates • Analysis of sedimentary regimes over time • Analysis of sediment dynamics WP Lead: PP7 - IRSTEA (Frédéric Liébault) Contributing partners: PP4, PP5, PP6, PP7, PP8, PP9, PP11, PP12, PP13	• Identification and quantification of sediment sources • Assessment of sediment connectivity • Estimation of sediment yield at different scales and for different geomorphic processes • Assessment of sediment cascades in relevant landscape settings including the disruption of continuity due to hydraulic structures • Historical analysis of basin responses to changing environmental conditions
WP5: Sediment transport monitoring Main objectives: • Sediment and wood transport monitoring at the selected study sites • Analysis of the spatial-temporal variability of transport processes • Harmonization of the monitoring programs and protocols • Comparison of field data with bedload and wood transport equations • Analysis of the interaction of sediment flux with river restoration interventions WP Lead: PP11 -BOKU (Helmut Habersack) Contributing partners: LP, PP1,PP2, PP3, PP4, PP5, PP6, PP7, PP8, PP9, PP11, PP12	• Sediment transport monitoring (suspended load, bedload, debris floods, debris flows, large wood), using existing monitoring sites (through direct and surrogate techniques) • Standardisation of methods and data collection on sediment transport • Analysis and assessment of the spatial and temporal variability of sediment fluxes at the monitoring sites • Evaluation and improvement of sediment transport equations and of available numerical models • Sediment transport monitoring in and evaluation of river restoration projects aimed at enhancing sediment and wood continuity

Titles, main objectives, work package lead, contributing partners	Main activities
WP6: Interactions with structures Main objectives: • Analysis of mutual interactions between torrent and river control structures, torrent and river sediments and large wood • Develop tools for improved concepts to design control structures • Study the interactions of different hydropower dams and sediment transfer • Evaluation of river hydro-morphological alterations WP Lead: PP9 – UL FGG (Simon Rusjan, Jost Sodnik) Contributing partners: LP, PP1, PP2, PP3, PP5, PP7, PP9, PP10, PP11, PP12, PP13	• Assessment of mutual interactions between control structures, torrential and river sediments, and large wood • Evaluation of the effects of hydropower dams on sediment continuity for design and planning purposes • Evaluation of river hydro-morphological alterations due to longitudinal sediment-continuity disruption and performance analysis of river restoration measures • Performance analysis and definition of optimal planning and design of torrent control works to reduce their impact on longitudinal sediment continuity
WP7: Sediment management Main objectives: • Analysis and assessment of sediment regime-fluxes-dynamics at different spatial and temporal scale • Analysis of interactions with existing and planned man-made structures WP Lead: PP3 – Università di Padova (Mario A. Lenzi) Contributing partners: : PP1, PP2, PP3, PP4, PP5, PP8, PP9, PP11, PP12	• Developing scaling approaches to link basin and channel processes • Estimation of present sediment transfer characteristics for the pilot basins • Estimation of sediment-wood budget for the reference "design flood" in the pilot basins • Assessment of different options for reservoir management (incl. "re-cycling" issues) in the context of the scaling-approach • Evaluation of the effects of sediment extraction for raw material use on sediment yield and related hydro-morphological aspects

SEDALP PROJECT

WP4: BASIN SCALE SEDIMENT DYNAMICS
WP5: SEDIMENT TRANSPORT MONITORING
WP6: INTERACTION WITH STRUCTURES
WP7: SEDIMENT MANAGEMENT



2.2 Description of pilot areas and case studies

A large part of the described monitoring activities, investigations and methods throughout all WP were developed, tested and validated in case studies covering all countries that were involved in the SedAlp project (Fig. 1 and Fig. 2).

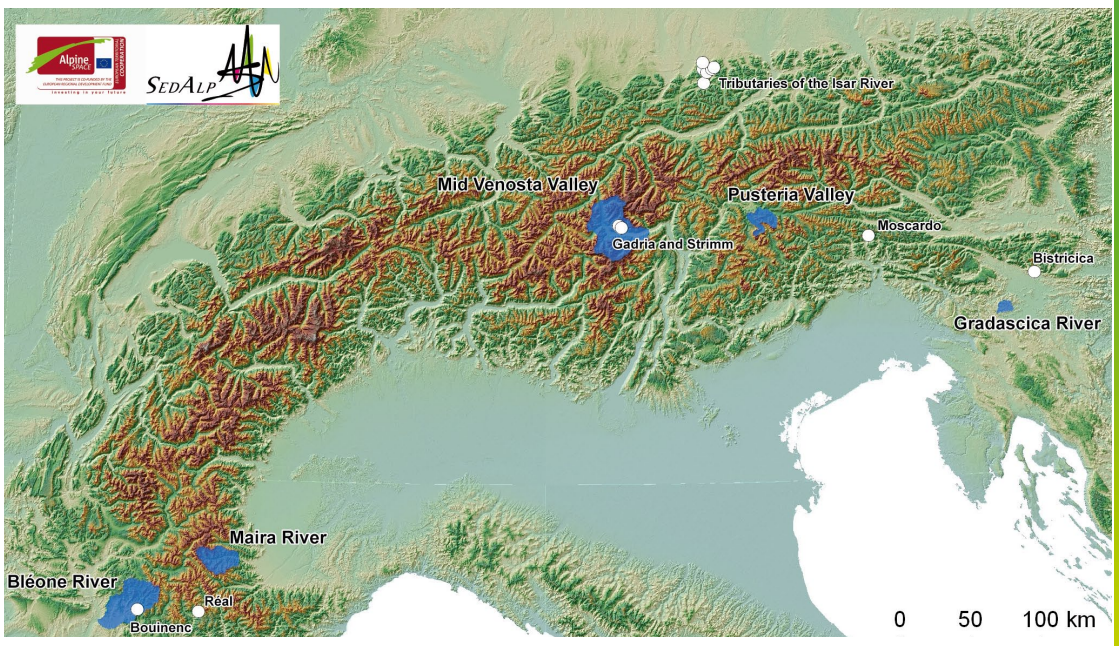


Fig. 1: Monitoring sites of the SedAlp project illustrated in different colours according to monitored processes

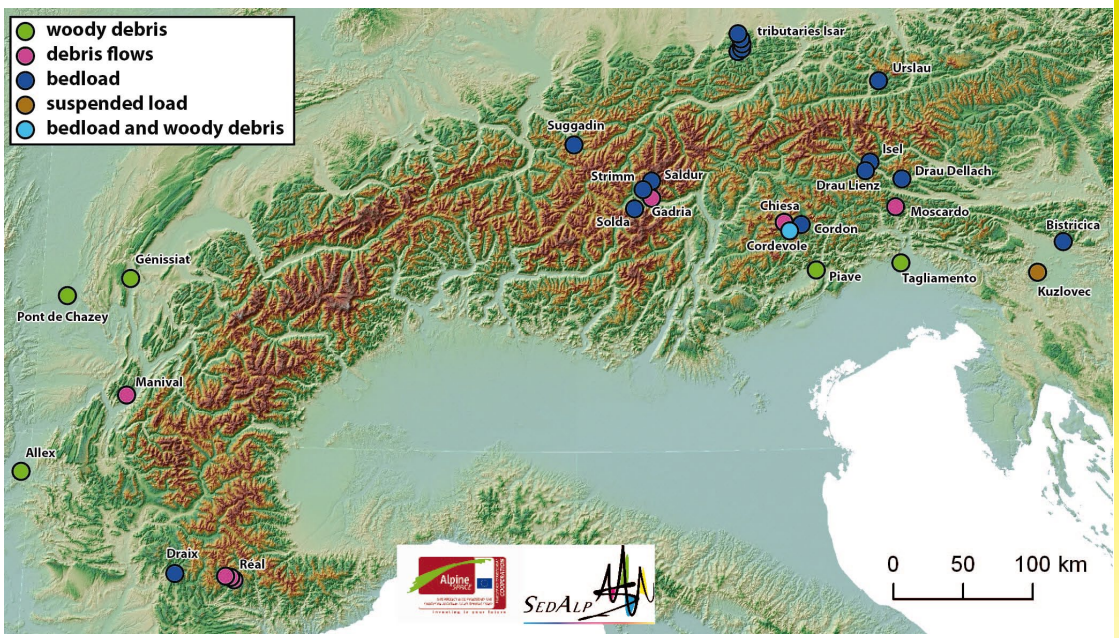


Fig. 2: Pilot areas and their catchments of WP4 in addition to Fig. 1

3 Key outputs

Sediment transfer through a mountain catchment can be regarded as a cascading system. Hillslopes and channel reaches represent elementary landscape units between which a wide variety of geomorphic processes transfers sediment (e.g., slope wash, rill erosion, landslides, debris flows and fluvial processes). These processes erode or remobilize sediments from sediment sources, i.e. areas on hillslopes or within the channel network where sediments are generated or stored. Adjacent landforms, for example a hillslope and a channel reach, are coupled if sediment delivery to the latter takes place, either by sediment transfer from the hillslope to the channel, or by bank undercutting and bank failure. However, it is not uncommon that hillslopes are decoupled from the channel network because sediments are deposited within the hillslope, in storage landforms, e.g., on the footslope, or on a floodplain bordering the channel. The same concept can be applied to adjacent channel reaches; they can be decoupled where (and when) the transport capacity is too low, for example, in (natural) low-gradient sections or due to artificial structures. The transfer of sediment by multiple processes links sediment sources to storage landforms and the catchment outlet, thus forming sediment cascades.

All coupling relationships within a catchment depend among others on topography, the spatial configuration of sediment sources and sinks, sediment properties, and the type and magnitude-frequency of processes that drive sediment transfer. Coupling is subject to change, for example the construction or removal of dams, or the formation of new sediment sources following a landslide. Such changes may affect sediment transfer on a longer timescale, so that the current state of a system is the product of both current conditions and former states of the system; this includes both the impacts of historical landuse change and the heritage of the Pleistocene ice ages. The degree to which a catchment is coupled is termed (sediment) connectivity.

According to the mentioned sediment-related processes in alpine catchments the key outputs of each WP are differentiated along 4 categories:

- Sediment production
- Sediment transport/transfer
- Sediment deposition/remobilization
- Integrated sediment cascade/management.

3.1 Sediment Production

- The automatic detection of active erosion on hillslopes from a remote-sensing approach has proved to be an efficient way for constraining sediment supply conditions at the regional scale.
- 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.
- Results indicate that punctual hot spots of erosion in the Alps are of critical importance for assessing the sediment input to alpine rivers, since they can erode at rates exceeding 10 cm/yr (measured over a 3-yr period).

3.2 Sediment Transport/Transfer

- New derived and publicly available dataset on sediment (suspended load, bedload and debris flows) and wood transport.
- Standardized data collection methods in sediment transport monitoring for transboundary exchange.
- Determination on spatial-temporal variability in sediment (suspended sediment, bedload and debris-flow) and wood transport.
- Opportunities and challenges in improving equations and models for predicting sediment and wood transport rates validated on field data.
- Automatic video monitoring of wood transport with recently developed detection algorithms is a promising monitoring technique for the future and should be applied on a larger set of reaches to evaluate its potential and transferability.

3.3 Sediment Deposition/Demobilisation

- Results of the evaluation of restoration projects with respect to measured sediment fluxes show that data concerning the past and the current sediment transport are mandatory and a catchment wide analysis of sediment regime is essential.

3.4 Integrated Sediment Cascade/Management

- Promote the historical analysis of alpine basins by combing historical records with high-resolution DEMs derived from LIDAR data.
- The Fluvial Corridor toolbox has been developed within the project allowing to extract a large set of riverscape features from DEM and vector layers, and to provide spatial aggregation into homogeneous segments and metrics characterizing each of them.
- GIS-based tools have been developed during the project to assess the spatial pattern of connectivity based on a spatially distributed index that can be computed on a high-resolution DEM.
- Guidelines for the planning/designing of efficient torrent control structures with low impact on sediment continuity between upstream torrential headwaters and downstream river reaches involves providing verifications of the obtained solutions with respect to the system performance at different scales. Depending on the problem complexity practitioners should be open to the consideration of deriving knowledge for the planning process from (i) backward-oriented indication, (ii) mathematical modelling and (iii) physical lab experiments.
- Guidelines for improved planning of hydropower plants aimed to improve the longitudinal sediment continuity between upstream torrential headwaters and downstream river reaches. Inside Management Plans focus should be on reservoir and dam characteristics, morphological and hydraulic parameters variations, ecosystem aspects and responses, catchment geological characteristics (to know the typology of sediment supply into the reservoir), analysis of the amount of catchment area that can increase the sediment transport and deposition into the reservoir, sediments analysis and removal operations, prevention measures for the river system (aquatic ecosystem protection, fishing and activities connected to river system downstream the dam). Techniques should be developed which supply the sediments into the channel reaches downstream the dam.

- Guidelines for the planning and designing of effective flood protection systems, river training and restoration projects that have lower impact on sediment continuity. Sediment transport should already be considered in planning stages of not only restoration projects. River engineering in general should be performed with the aim to maintain sediment transport dynamics, or to minimize negative effects on sediment transport while being aware of the consequences. Repeated consultation of the state of the art derived from research outputs would improve and optimize the applied engineering methods and may lead to better and/or more economic solutions.
- Guideline for the estimation of sediment budget, including large wood monitoring and scenarios determination to be used for flood mitigation in Alpine basins. Four main key outputs have been provided with the first guideline: (i) The Morphodynamics Evaluation Tool – as an extension of the River Scaling Concept - accounts for sediment supply and sediment transfer as preconditions for sustainable morphodynamics in river reaches; (ii) 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; (iii) The evaluation of the effective for bedload and for suspended load defined as the discharge that transports most of the sediment, represent a useful parameter for investigations concerning channel design; (iv) A GIS-based conceptual model designed and calibrated in order to reproduce LW input and its transfer along the fluvial network was developed.
- Guidelines for the identification of morphological impacts related to hydropower plants and gravel extraction. Two main key outputs have been provided with the second guideline: (i) A method for short term channel adjustment and precise geomorphic change detection by using LiDAR data for the dry areas and a colour bathymetry technique for assessment of both floods impacts and gravel extraction; (ii) 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).

In addition operationable guidelines, tools, formulas, etc., from the key outputs of each WP are listed and marked in the corresponding sediment-related process (Tab. 2).

Whereas the key-outputs in WP4, WP5 and WP7 are typical tools such as GIS-tools to characterize fluvial corridor networks and their sediment related data in homogenous reaches or application tools for sediment transport formulas, the key outputs in WP6 are mainly guidances and guidelines to improve planning of hydraulic structures or restoration works.

All within the SedAlp project received key outputs are focused on an improved sediment continuity within the river basins. Every guidance, guideline, tool or formula represent a small but important part meshed in this common objective.

Table 2: Developed tools during the SedAlp-project according to the sediment-related process

Wp	Tool Process	Production/ Erosion	Transport	Deposition	Remobilisation
WP 4	• Fluvial Corridor Toolbox	X	X	X	X
	• Connectivity Toolbox	X	X	X	X
WP 5	• Application tool for sediment transport formulas		X		
	• Database-tool for the storage of surrogate monitoring data		X		
	• Suitability classification of monitoring technics		X		
	• Sediment and wood transport monitoring guidance		X		
WP 6	• Decision-making process of defining the protection concepts in torrent control		X	X	X
	• Annual technical maintenance documentation "Removal of bed load deposits from sediment retentions dams"			X	X
	• Manual for operating and maintaining of sediment retention dams			X	X
	• Design of Sedminent traps with open check dams: A Review, Part 1 - hydraulic and deposition processes			X	X
	• Design of Sedminent traps with open check dams: A Review, Part 2 - woody debris problems			X	X
	• Torrent check dam failure hazard ranking			X	X
	• Proposal of coarse sediment removal and introduction downstream the dam channel reach			X	X
	• Multi Criteria Analysis (MCA)			X	X
	• Counter measures for mitigating bed degradation	X	X	X	X
	• Tools for planning river bed widening	X	X	X	X
	• Consideration of sediment transport in flood risk management		X		
	• Assessing the morphological spatial demand of rivers	X	X	X	X
WP 7	• River Scaling Concept - Morphodynamics Evaluation Tool	X	X	X	X
	• GIS based conceptual model for large wood input and transfer	X	X		
	• GIS methodological framework for targeting sediment management	X	X	X	X
	• Colour bathymetry technique for assessment floods impacts and gravel extraction	X		X	X
	• Effective discharge concept for bedload and suspended load	X	X	X	X

4 Recommendations

Analysis and applied methods in all WP in the SedAlp project lead to the following main recommendations for a sustainable sediment management providing a reliable decision basis for policy-makers, practitioners and researchers (Tab. 3-5). A detailed list of recommendations with additional remarks and information can be found in each WP-report.

Table 3: Main recommendations from all WP for practitioners

	WP4 Basin scale sediment dynamics	WP5 Sediment transport monitoring	WP6 Interactions with structures	WP7 Sediment management
Practice	• Sediment management strategies of alpine rivers must be based on a comprehensive basin-scale analysis of the sediment cascade	• Combination between direct and indirect suspended, bedload, debris-flow and wood monitoring techniques utilizing the most recent/ advanced state of research instruments and methods with continuous automatic systems.	• Consider new analysis and approaches concerning the sediment continuum in Reservoir Management Projects.	• Improve physics (hydrological regime, geological settings and lithology) and ecological (macro and micro fauna) knowledge of the studied areas at different scales
	• Promoting GIS and remote sensing approaches for sediment management in the Alpine Space	• Harmonize monitoring techniques, protocols and use standardized analysis procedures in order to compare monitoring results across the Alps.	• Protection concepts has to be process- and scenario-oriented with main focus on sediment continuity and integral water management.	• Long-term monitoring should include, as a minimum, hydropower plant-reservoir sedimentation surveys, with suspended sediment sampling and monitoring of reaches downstream
	• Relating a spatial characterization of sediment connectivity to sediment sources inventory	• Application of sediment and wood transport equations and numerical sediment transport models with great caution and calibrate and validate against monitored field data.	• Pay attention on the self-cleaning functionality of open barriers and regularly monitor and document the behavior of open structures	• Sluicing and flushing works in hydropower plant-reservoirs with knowledge of the calibre of sediment coming into a reservoir for effective operation
	• Integrating present-day sediment dynamics within the historical dimension of alpine basins	• The design of river restoration measures should be based on an improved process understanding between sediment transport and engineering measures.	• Repeated consultation of the state of the art derived from research outputs.	• Take into consideration the sediment connectivity between the upper and lower river reaches and analyse both types and characteristics of all the human structures built along the river network

Table 4: Main recommendations from all WP for policy makers

	WP4 Basin scale sediment dynamics	WP5 Sediment transport monitoring	WP6 Interactions with structures	WP7 Sediment management
Policy	• Promote a basin-scale approach of sediment management issues	• Long term sediment transport monitoring data should be managed, stored and quality assured by a public hydrographic service with access to practitioners	• Adequate risk-based land-use planning taking into account the threat from floods has to protect the areas for water and for sediments	• Promote data sharing and experience with common informatics databases for more robust evaluations of sediment and wood budgets
	• Support the collection of high-resolution LiDAR surveys of alpine catchments, and make data available at no or low cost	• Improve long term data bases on sediment transport, particularly in catchments where the sediment management is a main topic as in those strongly influenced by hydropower exploitation and hydrogeological risk mitigation measures	• Assure enough time and resources for expert assessment of the existing status of water/ sediment regime on large scale of whole river basin after extreme events.	• Old laws should be amended, providing mechanisms for encouraging landowner to reduce erosion and siltation
	• Establish and maintain accessible archives of historical aerial photographs in digital form	• Establishment of a network of similar sediment and wood monitoring stations among the same country and also throughout transboundary collaborations and interchange	• Promote timely and adequate monitoring and maintaining of existing water-infrastructures/ protection constructions to preserve their protective function	• Develop managing strategies for restoring rivers and floodplains in the contest of constraining legislative frameworks (e.g. the Water and Flood Risk directive within the European Community)
	• Promote research on sediment continuity in alpine basins and maintain a substantial level of scientific investment	• Guarantee the availability of skilled personnel to perform measurements at extreme flood events and implement sediment monitoring and analysis techniques also at universities.	• Maintenance of existing facilities should be given priority over the construction of new; damaged structures do not protect but offer a deceptive impression of security.	• Incentivize good strategies of sediment and large wood management (long-term monitoring programmes and encouraging cycle management approaches in lieu to design life approach)
		• Improvement of the links between research and application/management regarding "immediate" knowledge and technique transfer from basic research to practice	• Forward targeted, consistent risk dialogue with all of the parties involved in sediment management in related basin in order to strengthen prevention efforts and promote adopted approach for optimizing sediment continuity.	• Long term monitoring of suspended sediment transport in relation to fish and acquatic habitat management, conservation and restoration.
			• Set-up systemic and long-term knowledge-experiences-sharing official "sediment management networks" on regional, national and international levels.	
			• Be aware that solving sediment connectivity related problems, might entail strong modifications of existing protection systems originally designed to retain rather than to activate sediment dynamics.	

Table 5: Main recommendations from all WP for research

	WP4 Basin scale sediment dynamics	WP5 Sediment transport monitoring	WP6 Interactions with structures	WP7 Sediment management
Research	• Promoting integration of GIS and field-based approaches of the sediment cascade	• Closer integration between the monitoring of various sediment transport processes in Alpine headwaters.	• Further implementation of long-term data collection, analysis and survey of sediment retention basins	• Integrated collaboration between different scientific disciplines effects (e.g. engineering, ecological, geological and morphological)
		• Establish long term sediment monitoring programs in order to capture global or regional changes.	• Further research on management of sediment connectivity at different spatial and time scale and improving of construction types.	• More precise estimation of sediment and wood budget at different spatial and temporal scales is needed, such as a more thorough analysis of the interaction between sediment-wood and transversal structures
		• Integrate debris-flow monitoring with suspended load and bedload measurement with observations on sediment sources evolution and channel changes.	• Further research on management of sediment connectivity at different spatial and time scale and improving of construction types.	• Consider both bed load and suspended load, their characteristics, the trapping potential and downstream impacts of fine and coarse sediment considered separately
		• Further develop sediment monitoring and modelling tools and methods, e.g. by combining direct and indirect measurement methods	• Support policy makers and practioners for the best strategies of sediment management.	• Develop new techniques of reservoirs and transverse structures management solutions focused on the sediment continuity, seeking to balance sediment inflow and outflow across the reservoir while maximizing the long-term benefits and minimizing impact on the river environment and mantain biological diversity
		• Analyse monitoring data to study fundamental processes, their mathematical description and implementation into models	• Future research should find a balance with field verification, implying a close collaboration with policy makers and practitioners.	

5 Annex

5.1 Milestones

- Protocol for data collection method in sediment transport
- GIS-based tools for sediment management in river basins
- First set of practically applicable bedload/wood transport reports and models

5.2. References to project/scientific publications

5.2.1. WP4 publications

Peer-reviewed papers and proceedings:

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5.2.3. WP6 publications

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5.2.4. WP7 publications

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5.2.5. WP8 publications

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Project partners

Austria

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

France

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

Germany

- Bayerisches Landesamt für Umwelt

Italy

- Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto
- Consiglio Nazionale delle Ricerche - 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
- Enel Produzione SpA
- Enel Produzione SpA – UBI Hydro Piemonte
- Enel Green Power SpA
- Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft
- Illwerke AG
- Istituto Superiore per la Protezione e la Ricerca Ambientale
- 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

Notes

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

European Territorial Cooperation Alpine Space 2007-2013

Priority 3 - Environment and Risk Prevention

Timeframe 2012-2015