PUBLIZIERBARER Endbericht Studien

(gilt nicht für andere Projekttypen)

A) Projektdaten

Titel:	Risk assessment and management of Riparian ecosystems in condition of Climate Change in Austria (RIPCLIMA)
Programm:	ACRP, 1. Call
Koordinator/ Projekteinreicher:	eb&p Umweltbüro GmbH Priv. Doz. Mag. Dr. Gregory Egger
Kontaktperson - Name:	DI Dr. Karoline Angermann
Kontaktperson – Adresse:	Bahnhofstraße 39 9020 Klagenfurt
Kontaktperson – Telefon:	0699-12905560
Kontaktperson E-Mail:	Karoline.angermann@umweltbuero.at
Projekt- und Kooperationspartner (inkl. Bundesland):	BOKU – Universität für Bodenkultur, Wien Institut für Wasserwirtschaft, Hydrologie und konstruktiven Wasserbau
Projektwebsite:	-
Schlagwörter:	Auenvegetation, Ufervegetation, Natura 2000 Gebiete, Naturschutz, Gewässermanagement, Biotoptypen, Entscheidungshilfe, Decision Support System, Modellierung, Klimawandel
Projektgesamtkosten:	€ 159.442,--
Fördersumme:	€ 159.442,--
Klimafonds-Nr:	A963615
Projektstart & Ende	01.10.2009-30.09.2011

B) Projektübersicht

1 Executive Summary

[Deutsch]

Im Projekt RIPCLIMA werden für Entscheidungsträger, die mit Fließgewässermanagement und Naturschutz zu tun haben, fundiertes Wissen und Werkzeuge zur Entscheidungshilfe über die Wirkung des Klimawandels auf Ufer- und Auenvegetation erarbeitet.

Globale Klimaszenarien sagen eine Änderung des hydrologischen Regimes von Fließgewässern und damit eine Änderungen von physikalischen Prozessen voraus. In diesem Projekt wurde die Auswirkung des Klimawandels auf die von diesen Prozessen gesteuerten Gewässerökosysteme untersucht, modelliert und quantifiziert. Der Schwerpunkt wurde dabei auf die Ufer- und Auenvegetation gelegt. Das Projekt wurde auf zwei räumlichen Ebenen bearbeitet: Auf der Österreich-Ebene wurde ein Decision Support System entwickelt, das die qualitative Wirkung des Klimawandels auf die Ufer- und Auenvegetation und das Risiko von Habitatverlusten analysiert. Mit einem besonderen Augenmerk auf Natura 2000 Gebiete wurden dafür österreichweit verfügbare Informationen über die Ufer- und Auenvegetation herangezogen. Auf der lokalen Ebene wurden zwei Fallstudien in Österreich (Obere Drau in Kärnten und Tauglgries in Salzburg) detailliert untersucht. Dafür wurden hydraulische und morphodynamische Modelle verwendet und mit diesen die Triebkräfte für Wachstum oder Störung von Ufer- und Auenvegetation simuliert. Mit einem dynamischen Vegetationsmodell wurde unter Berücksichtigung dieser simulierten Störungen die langfristige Entwicklung der Vegetation modelliert. Alle Modelle wurden auf die spezielle Fragestellung angepasst und weiterentwickelt. Um die Unsicherheiten bei der Prognose des Klimawandels zu berücksichtigen, wurden jeweils unterschiedliche Szenarien untersucht.
Auf der lokalen Ebene zeigen die Ergebnisse, dass die Eingriffe der Menschen in den letzten Jahrhunderten, wie Landnutzung, Regulierungen oder Kontinuumsunterbrechungen, zu einer dramatischen Änderung morphodynamischer Prozesse geführt haben. Der Effekt des Klimawandels wird – je nach betrachtetem Szenario – diesen Einfluss verstärken oder teilweise auch verringern. Die Autoren können mit dem Projekt zeigen, dass bei (weiterer) Verringerung der natürlichen, morphodynamischen Prozesse nicht nur viele Habitate verloren gehen, sondern dass das Fehlen natürlicher Störungen in der Vegetationsentwicklung, wie sie bei der Ufer- und Auenvegetation charakteristisch sind, zu einer starken Verarmung der Biodiversität führt, da z.B. junge Pionierphasen kaum noch vorkommen. Auf der Österreich-Ebene zeigt ein Szenario mit geringeren jährlichen Abflussspitzen, selteneren Hochwässern und trockeneren hydrologischen Verhältnissen eine Regression bei 16 von 22 auenspezifischen Biotoptypen. In Regionen, wo diese Biotoptypen jetzt schon selten sind, ist folglich das Risiko des Habitatverlusts sehr hoch. Ein anderes Szenario nimmt höhere jährliche Abflussspitzen, häufigere Hochwässer und ebenfalls und trockenere hydrologische Verhältnisse an. Dies führt zu einer Erhöhung morphodynamischer Prozesse im Fließgewässer und in Folge häufig zu positiven Effekten für auenspezifischen Biotoptypen. Insgesamt würden von diesem Szenario 8 Biotoptypen profitieren.

[English]

RIPCLIMA is a strategic project designed to give scientifically based knowledge and decision support tools to stakeholders, who are in charge of water management and nature conservation. RIPCLIMA aims to gain new knowledge and understanding of the impacts of climate change on riparian ecosystems and finally to improve existing strategies for management. Based on the project insights, riparian ecosystems could be managed in a sustainable manner with respect to biodiversity conservation, ecological and economic goods and services.

Global scenarios for climate change in Europe assume changes in river discharges. Altered hydrological regimes will lead to changes in physical processes associated with these regimes and its ecosystems. Riparian ecosystems of Austria have large contribution to environmental and socio-economical services and goods like hydropower, water supply, navigation and leisure activities, irrigation and effluent disposal etc. These impacts put strong pressure on riparian ecosystems and impact their ability to provide values and functions. In this project climate chance impacts on riparian ecosystems were studied, modeled and quantified by bringing together hydrological, environmental and meteorological disciplines.
The project is articulated in different scales: At the Austrian scale a decision support system was developed for qualitative analysis of the impact of climate change scenarios on the risk of considerable habitat loss. Information about overall Austrian riparian ecosystems was considered with special regard to Natura 2000 sites. At the local scale detailed analysis and quantification of climate change impacts were done. Two study sites were investigated in Austria (Upper Drau in Carinthia and Tauglgries in Salzburg). For this task, hydraulic and morphodynamic models were improved and applied to simulate the driving forces of riparian vegetation. The development of riparian vegetation was simulated using a dynamic vegetation model that was also improved within the project. In order to handle the uncertainties of climate change effects on hydrologic parameters, different scenarios were defined and assessed.
At the local scale the model results show that in the last centuries human impacts, like land use changes, channelization or continuum interruptions, have led to dramatic changes in morphodynamic processes. The effect of climate change scenarios will partially strengthen and partially weaken these impacts. The authors would like to stress, that based on the investigations carried out at the study sites, maintaining an active riparian vegetation turnover is important; if morphodynamic processes are reduced these ecosystems will gradually be degraded and typical habitat elements such as young pioneer phases will be lost. Assuming a scenario with lower peaks of annual floods, lower frequency of floods and in general dryer hydrologic conditions at the Austrian scale, a regression is expected for 16 out of 22 riparian biotope types due to climate change. In regions where these biotopes are currently rare the risk of habitat loss is really high. Another scenario assuming higher peaks of annual floods, a higher frequency of floods and also dryer hydrologic conditions, leads to an increase of morphodynamic processes in the river, which leads to a positive effect on many biotope types. All over Austria 8 biotope types are expected to benefit from this development, no biotope type is expected to be regressed. Anyway for 9-12 biotope types the trend is undetermined for this scenario.

2 Hintergrund und Zielsetzung

Initial situation

Global scenarios for climate change indicate changes in air temperature, precipitation and hence discharge in Europe. Altered hydrological regimes will lead to changes in physical processes in running waters, and the timing, duration and magnitude of floods and droughts will most probably increase in most regions. This may lead to quite dramatic changes in running water ecosystems, especially affecting the abundance and performance of riparian vegetation and values and functions provided by them.

Running waters constitute the major part of Austrian water resources. In spite of small surface the riparian ecosystems of Austria have big contribution to biodiversity, by providing the place and primary productivity upon which countless species of plants and animals depend for survival. These systems are also used for a variety of social and economic purposes, including hydropower, water supply, navigation and leisure activities, irrigation and effluent disposal. These activities put strong pressure on riparian ecosystems and impact their ability to provide values and functions. Each change in these systems will have negative impact not only on biodiversity, but also on people, for whom these ecosystems are playing important role and whose livelihood depends from these ecosystems.

The knowledge about the impact of climate change on riparian ecosystems is fragmented, incomplete and lacks integration into the wider social-economical practices. In this project components of an integrated hydrodynamic vegetation model for riparian ecosystems are developed which will give possibility to study, model and quantify the impacts of climate change on Austrian riparian ecosystems. New and updated knowledge on adaptation measures to climate change impacts including uncertainty in the context of specific riparian ecosystem management challenges on the basis of specific regional modeling and scientific investigations in Austria are obtained, which give possibility to develop appropriate risk analyses and management options for mitigation, adaptation and restoration of direct and indirect effects of climate change.

Recent development has shown the possibility of transferring knowledge into simulation models. Models are very useful for a better understanding impacts of changes (including the effect of climate change) on riparian ecosystems, which is often long term and always dynamic, and have predicting ability to simulate future conditions based on different scenarios. The modeling is serving as a tool that support water managers decisions related to the riparian vegetation and ecological status in different river types. Based on the modeling results a Decision Support System is developed for impacts of climate change on Austrian riparian ecosystems. For achieving the objectives, the project is implemented on two scales: Austrian scale and study site scale.

Objectives

The objectives of the project RIPCLIMA were:

- Study, model and quantify impacts from climate change on Austrian riparian ecosystems by bringing together hydrological, environmental and climatic disciplines
- Provide a better understanding of direct and long-term impacts of environmental alterations caused by climate change on riparian ecosystem
- Develop appropriate risk analyses and management options for mitigation, adaptation and restoration for direct and indirect effects of climate change
- Develop hydrodynamic vegetation model for riparian ecosystems: including current hydraulic, morphodynamics, sediment and vegetation models.
- Deliver new and updated knowledge on adaptation measures to climate change impacts including uncertainty in the context of specific riparian ecosystem management challenges.
- Study and analyze the impact of different human activities on riparian ecosystems in long term perspectives in condition of climate change.

- The project will identify what thresholds leading to ecosystem vulnerability (and possibly virtuality) and what changes in ecosystem status and reference conditions are caused by climate change, especially for Natura2000 areas.
- Special Decision Support System has been developed for cost-effective adaptation strategies and measures in the river basin management field.

3 Projektinhalt und Ergebnis

Structure of the RIPCLIMA project

The project is structured into four work packages (WP) with different tasks:
WP 1: Project coordination
WP 2: Hydrodynamic, morphodynamics

- Derivation and analysis of climate change scenarios in Austria
- Development of a hydro-morphodynamic model to study climate change effects on hydraulics, sediment transport and morphodynamic

WP 3: Riparian vegetation

- Identification of changes of riparian vegetation in Austria
- Detailed analyses of riparian vegetation in study sites
- Identification of endangered riparian ecosystems in Austria by climate change
- Preparation of conservation measures for endangered riparian ecosystems

WP 4: Decision Support System

- Development of Decision Support System (DSS) for riparian ecosystems in Austria
- Development risk analyses of predictive climate change scenarios

Study sites
The project is implemented on two scales: Austrian scale and local “study site” scale. At the study site scale two river sections are investigated, Kleblach in Carinthia and Tauglgries near Bad Vigaun in Salzburg:

Kleblach: The study site Kleblach is situated on a river widening section of the Upper Drau River close to the village Kleblach – Lind in Carinthia, Austria (Figure 1). The Upper Drau River is one of the last stretches of large rivers of the Alps without hydropower use. Many rare and protected plant and animal species inhabit this river segment. The Drau River was designated as Natura 2000 area, which gives great importance to protection and improvement of the state of natural processes, plant and animal species and habitats.

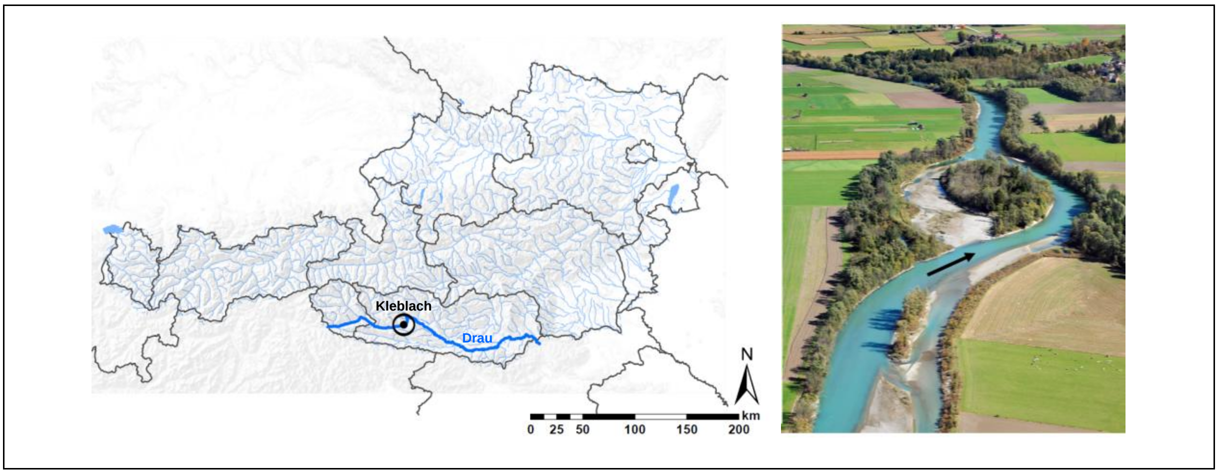


Figure 1: Position of study site (left) and aerial photo of the river widening section from 2007 (right). (map: DigHAÖ and photo: Federal Government of Carinthia)

<u>Tauglgries:</u> The site takes its name from the Tauglgries natural reserve area; the site lies along the Tauglbach river which is a right tributary of the Salzach river, near Salzburg (Figure 2). Tauglbach is one of the last unspoiled, free flowing rivers of Austria. These characteristics make a valuable asset from it which must be protected and at the same time can afford precious scientific material to understand riparian dynamics in undisturbed natural conditions.

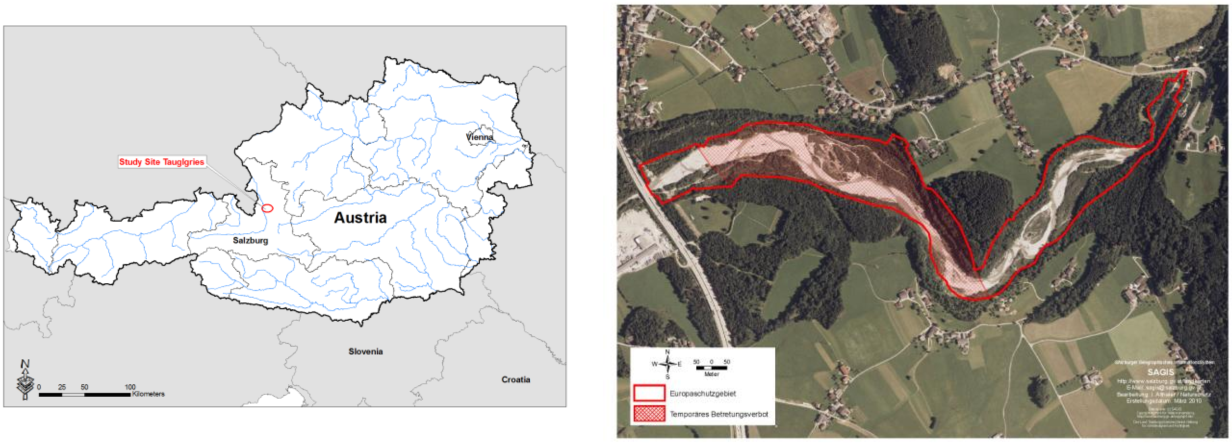


Figure 2: Tauglgries site location

Activities and work package (WP) description

Below for each work package the following chapters are described:

- Objectives
- Work proposed
- Description of results

WP 1: Project coordination

<u>Objectives</u>

Successful project implementation, fulfilling objectives of proposal, respecting timetable and project costs

<u>Work proposed</u>

Accompanying project coordination (project planning, organization of meetings, checking data availability of case studies, doing the interim report, supporting communication and organization, involvement and information of stakeholders, …)

WP 2: Hydrodynamic, morphodynamics data and modelling

Objectives

The main objective of this WP is to derive and analyze climate change scenarios and impacts on the hydro-morphodynamics based on numerical modeling.

Work proposed

- Derivation and analysis of climate change scenarios for Austria
- Quantification of climate change impacts on hydrology, hydraulics and morphodynamics
- Enhancement of hydrodynamic model by including a dynamic vegetation roughness sub model
- Allocation of input parameters for the vegetation model based on hydrodynamic – numerical modeling of the study sites Kleblach-Lind and Tauglgries
- Determination of flood duration in Kleblach based on different geometries and hydrographs
- Investigation of morphological changes at the study site Kleblach to demonstrate the opportunities of applying sediment transport models in the context of vegetation modeling

Results

Possible change of hydrology due to climate change in Austria

The **temperature** in the next century will increase between 2.5 and 4°C (Nachtnebel, 2008). The increase in winter is smaller in the east than in the west and during summer the increase is higher in the south than in the north (Böhm, 2008). The **precipitation** is also likely to change over space and time. It will increase during winter and decrease in the summer half-year (Gobiet and Truhetz, 2008)

The change of precipitation in quantity, the change of precipitation type and the seasonal shift of precipitation, as well as due to the expected conditions of the glaciers in the year 2100, implications of the climate change on **runoff** can be assumed. A decrease of the annual runoff is expected (Böhm et al., 2008). In alpine regions the runoff will be more balanced over all seasons. The **runoff regime** is also likely to change from glacially influenced to nival or pluvial driven (Schädler et al., 2007).

The climate change induces a higher frequency and a temporal shift of **low flow periods**. Changes in **floods** are also likely, but due to uncertainties within the used models (GCM`s, RCM`s, hydrological models) and too short data series (only a few observed major flood events) only rough estimates in which direction they will change, can be made (Gobiet and Truhetz, 2008). Therefore sub scenarios for hydrological changes were derived and used for the vegetation model.

The derived **sub scenarios** (Table 1) consist of following changes in hydrological variables and cover all reported developments of these variables: (1) decrease of runoff, (2) change of annual floods – increase and decrease possible, (3) change of floods – more or less frequent, (4) Increase of low flow periods and (5) seasonal change in runoff.

Table 1: Hydrological sub scenarios

Hydrological variables	Sub Scenario			
	A1B-A	A1B-B	A1B-C	A1B-D
annual runoff	decrease			
annual flood peaks	lower	higher	lower	higher
floods ($HQ_{10-1000}$)	less frequent	less frequent	more frequent	more frequent
low flow periods	increase			
seasonal change of runoff	shift of up to two classes			

Short and long-term impacts from climate change on hydrology, hydraulics and morphodynamics

For each investigated hydrological variable the impacts on hydraulics and morphodynamics are shown in Figure 3. The effects of the combined hydrological changes (sub scenarios) on mean discharge (MQ), annual floods and larger floods (HQ10-1000) were defined and their consequences on the bed shear stress (T), water depth (d), flood duration (whole year (DuFl(YearP)) and vegetation period (DuFl(VegP))) and flood frequency (whole year (FreFl(YearP)) and vegetation period (FreFl(VegP))) were identified for the river channel (RC) and the bank zone (BZ). The results are presented in Table 2

.

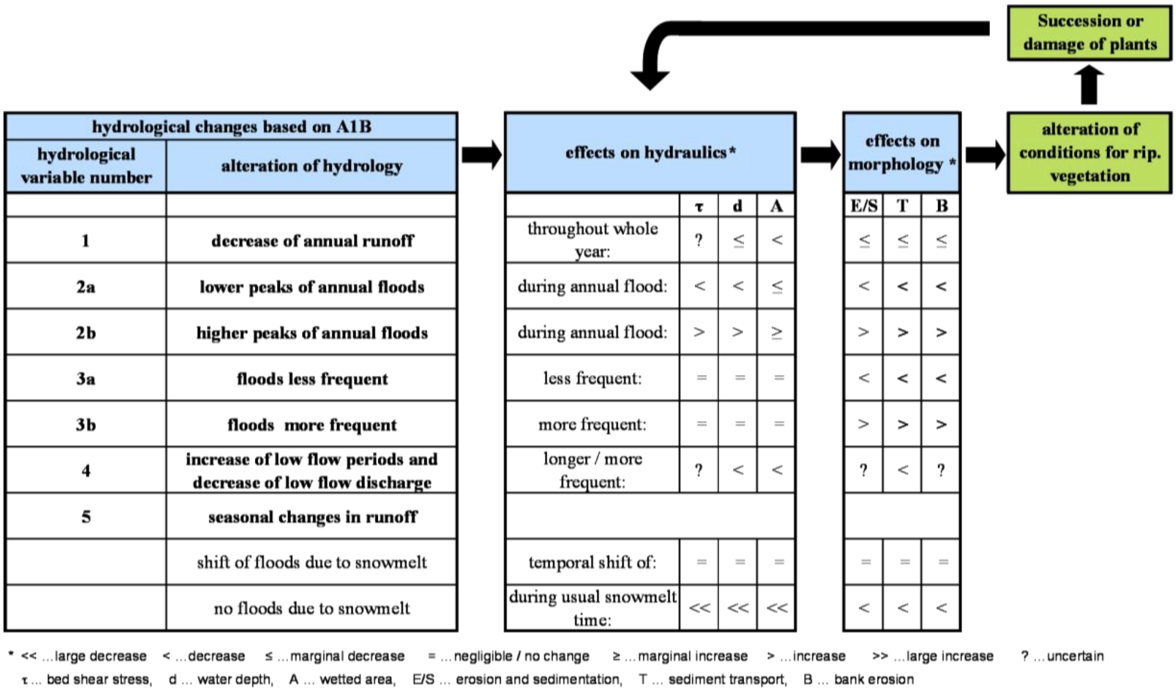


Figure 3: The Impacts of hydrological changes on hydraulics and morphodynamics

Table 2: Effects of subscenarios on hydraulic variables. The impacts are often uncertain, especially for annual floods, as they depend on the regime and the river geometry.

	MQ		annual floods		$HQ_{10\ to\ 1000}$		Szenario
	RC	BZ	RC	BZ	RC	BZ	
τ	?	= (no or negligible change)	?	? (uncertain if annual floods reached bank zone before and as there is a temporal shift of floods, the occurrence of annual floods may be altered (depending on the flow regime))	=	=	A1B-A
d	≤	=	?	?	=	=	
DuFl (VegP)	≤	=	?	?	?	?	
DuFl (YearP)	≤	=	?	?	?	?	
FreFl (VegP)	?	?	?	?	<	<	
FreFl (YearP)	≤	=	?	?	<	<	
τ	?	= (no or negligible change)	?	?	=	=	A1B-B
d	≤	=	?	?	=	=	
DuFl (VegP)	≤	=	?	?	?	?	
DuFl (YearP)	≤	=	?	?	?	?	
FreFl (VegP)	?	?	?	?	<	<	
FreFl (YearP)	≤	=	?	?	<	<	
τ	?	= (no or negligible change)	?	?	=	=	A1B-C
d	≤	=	?	?	=	=	
DuFl (VegP)	≤	=	?	?	?	?	
DuFl (YearP)	≤	=	?	?	?	?	
FreFl (VegP)	?	?	?	?	>	>	
FreFl (YearP)	≤	=	?	?	>	>	
τ	?	= (no or negligible change)	?	?	=	=	A1B-D
d	≤	=	?	?	=	=	
DuFl (VegP)	≤	=	?	?	?	?	
DuFl (YearP)	≤	=	?	?	?	?	
FreFl (VegP)	?	?	?	?	>	>	
FreFl (YearP)	≤	=	?	?	>	>	

Evaluation of interactions between vegetation and hydraulics and implementation of vegetation roughness sub model into a hydrodynamic-numerical model

The main **effects of vegetation on the flow and river morphology** are the change of roughness, the change of flow velocity and flow direction, the trapping and distribution of sediment, and the stabilizing effect on the river bed by increasing cohesion of soil and by decreasing the near bed flow, inhibiting sediment resuspension.

As the alteration of roughness due to the vegetation is an essential part in modelling the hydraulic conditions and in succession the morphodynamics, a **sub model**, based on the iterative calculation of bending angles of plants, was developed and implemented into a hydrodynamic-numerical model. The model uses the drag force, plant properties and vegetation densities to determine the roughness. It can be applied for rigid and flexible plants in emergent and submerged conditions.

Detailed analyses and modelling of hydrodynamics and morphodynamics

The results of the hydrodynamic simulations revealed the **differences in hydraulic parameters** (flow velocity, water depth and bed shear stress) based on the different discharges modeled and, especially for Kleblach, based on the different digital elevation models used. The influence of the changing river morphology on the hydraulic parameters was evident. The alteration of morphology changes the magnitude of on the plant and habitat applied stresses (flood duration, distance to the groundwater, bed shear stress,…) and was thus identified to change the conditions for recruitment and plant growth. The application of a morphodynamic model for the study site Kleblach revealed the **opportunities of sediment transport modeling** in vegetation modeling.

Further it has to be stated, that the entire morphological development and vegetation development is depending on the sediment input and thus the overall catchment based **sediment regime**. Thus an interruption of the sediment continuum and thus a reduction of sediment input would lead again to riverbed erosion and disappearance of morphodynamics, especially gravel bars.

Allocation of input parameters for vegetation model based on hydrodynamic-numerical modelling

The input parameters were prepared as raster maps and used in the Vegetation model (Figure 4).

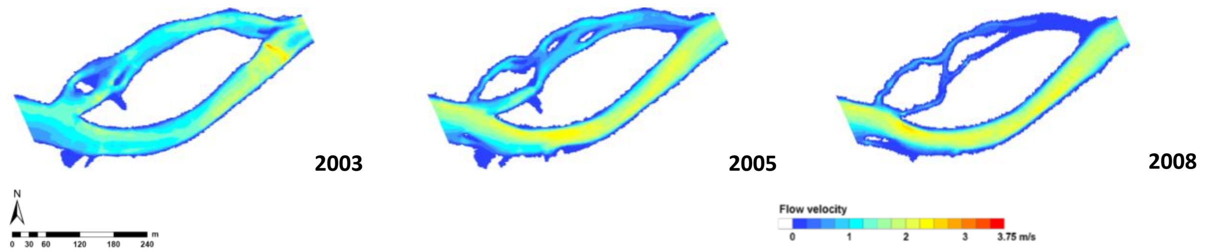


Figure 4: Results – Kleblach: flow velocity (v) and water depths (d) MQMay-June

Determination of flood duration at Kleblach for different geometries and hydrographs

The hydrology (annual hydrograph) and the morphology determine the period of submergence of a particular spot. The investigations of the flood duration revealed, that based on the digital elevation model of 2008 more areas are suitable for vegetation due to an increase of less often flooded areas (evolved gravel bars).

WP 3.1: Riparian vegetation changes at the study sites

Objectives

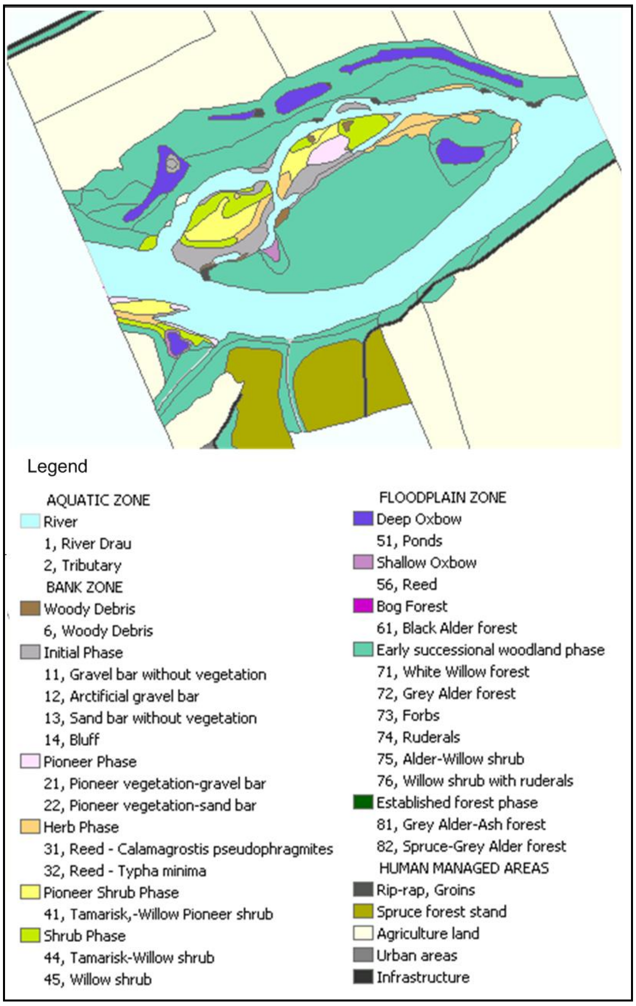
Given the relationships climate-hydrology and hydrology-riparian vegetation is legitimate to argue that climate change is affecting also the wealth of riparian vegetation. However, although the syllogism appears to be correct, the quantification of these climate change induced impacts cannot proceed in a speculative fashion and requires means of assessment. The quantification of these affections is the main objective of this work section which aims to measure the impacts of climate change on the Alpine riparian vegetation. Quantification is carried out by comparing baseline and climate change induced vegetation spatiotemporal distribution modeling.

Work proposed

- Vegetation mapping of case study sites Kleblach and Tauglgries
- Case studies sites characterization
- Calibration of the dynamic vegetation models (both case study sites)
- Hydrologic inputs classification
- Modification of hydraulic data for climate change scenarios
- Dynamic vegetation model application (both case study sites)
- Analyzing and discussion of results

Results

Vegetation characterization of case study sites



For the Kleblach case study, were available field mapping data for several years. Vegetation types and their correspondence to succession phases at Kleblach are depicted in Figure 5 (Vegetation map of 2010).

Figure 5: Vegetation mapped at Kleblach in 2010. Legend encompasses the vegetation types of each succession phase, grouped by riverine zone

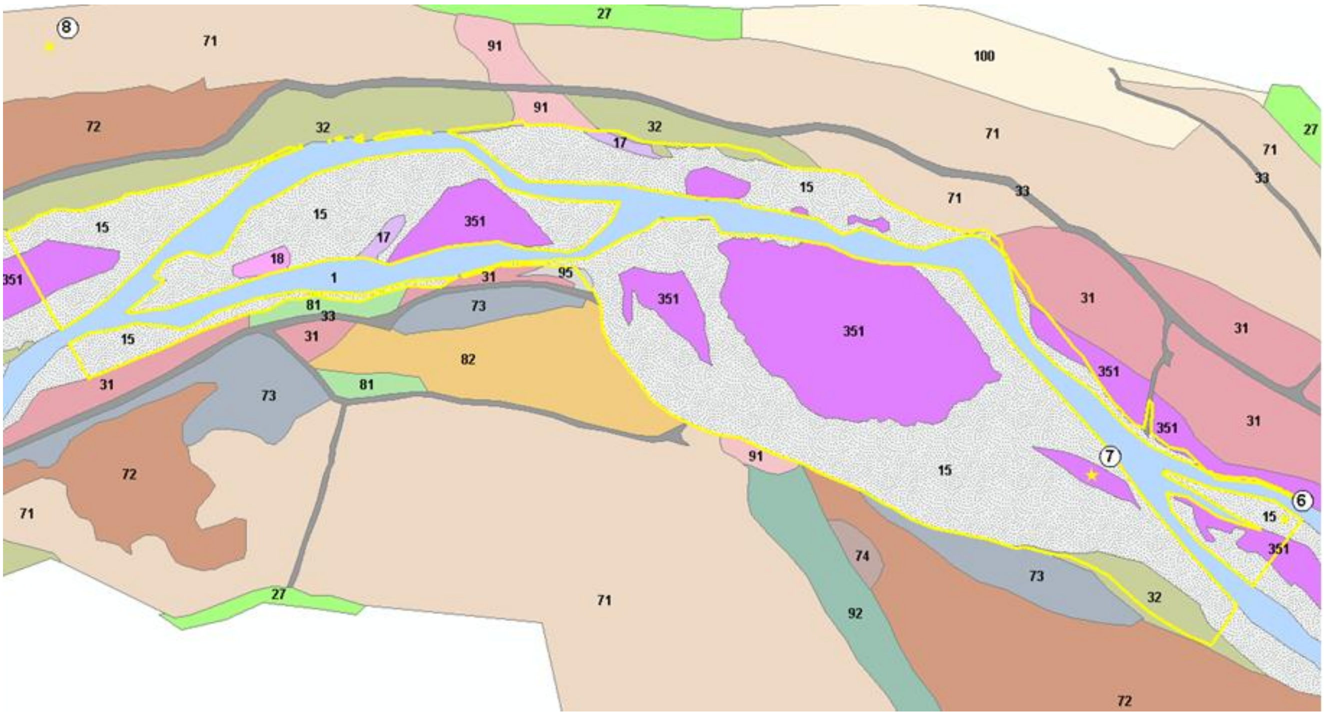


Figure 6: Vegetation types mapped at Tauglgries in 2011

Figure 7: Tauglgries landscape view

The case study site of Tauglgries is an impressive example for braided alpine river flowing over limestone bedrock. The system is characterized by a very high bed load transport from the catchment area and also from side erosion. In the 1970's consistent loads of sediment were removed from the system and used for building the adjacent. As a consequence, the active cannel level decreased of several meters and the floodplain zone was disconnected from the active channel. At nowadays the bed load transport has been restored; and the bed sediment balance is positive (bed elevation is increasing), nevertheless, the former floodplain zone is not expected to be fully reconnected to the active channel, at least in next decades.

Vegetation model application: reference period and climate change scenarios
Kleblach baseline reference is characterized by an active turnover among the different vegetation patches composing a various landscape mosaic while simulation endpoints return a quite static picture (see Figure 8). In the simulation of reference period, this is certainly due to the static morphology applied in the modeling while for the climate change scenarios, this condition is accentuated by the climate change induced ecosystem perturbations. Either way, it is clear that, less lateral erosion occurs, when a river system like Kleblach is stabilized by bank protection. As a consequence, morphodynamic processes are reduced and the ecosystems turnover is impaired, there is a loss of biodiversity and ultimately a decrease of ecological functionality.

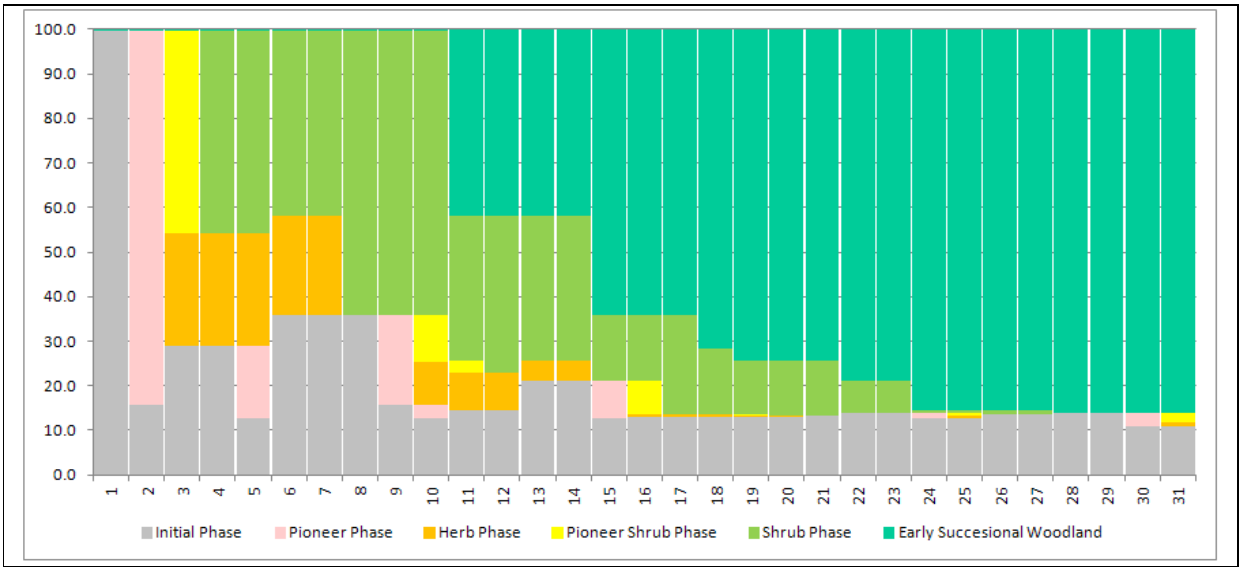


Figure 8: Bank zone relative area balance of scenario K1 (dry and lower floods)

At **Tauglgries** a general lack of densely distributed vegetation patches and recruitment areas is observed as a consequence of high morphodynamic disturbance and the diffuse dryness. Observing the scenarios differences, the change of recruitment area within the different scenarios (+/-25% change of annual flood) is not very significant and under the range of uncertainty of the model. Nevertheless, in case of scenario T2 and T4 (increase of floods) the recruitment area is lower than in T1 and T2 (see Table 3). Although subject to uncertainties, such little decrease could however play a major role and its effects must not be underestimated. For some species, in fact, this could be crucial because their area could be reduced below the minimal extension required to maintain a local population. Ultimately, for the well being of the Tauglgries riparian ecosystem, the bed load transport from the catchment area is very important and – especially regarding potential for recruitment – the lateral erosion must be maintained.

Discussion
The data availability for Tauglgries was not in that quality than it was for Kleblach. The choice of using the groundwater table calculated for 25 m^3/s has been forced by the technical impossibility of producing a groundwater table for the typical (but very low) discharges of the spring period. The remaining areas, not included in the recruitment range, are considered too high (and consequently too dry) to afford suitable sites for recruitment. After several model runs, it was clear that the recruitment range was too broad and therefore it has been slightly reduced. The mapping in the field has shown that naturally there are very few fine soil areas with silt and sand substrate and more or less wet conditions. Therefore recruitment area is generally rare and the layer of the spring water level have less influence to the system, upon these considerations, the recruitment parameters have been re-defined. For the Tauglgries hydraulic model input only laser-scan data were used to set up the topography (DEM). Analyzing the results it was observed that even at HQ_{10}, not all the site is flooded and there are some areas with very low shear stress values which is a condition in contrast to what it has been observed in

field. Such inconsistency is surely due to the scarce precision that the DEM used in the hydraulic modeling has in some study site areas. The modeling results of Tauglgries were discussed in consideration of this inconsistence.

WP 3.2: Riparian vegetation changes on Austrian scale

Objectives

- Define impact of climate change on riparian vegetation for overall Austria
- Show the risk of considerable habitat lost for Natura 2000 sites with riparian vegetation
- Develop conservation measures and define risks

Work proposed

- Identification the changes in riparian vegetation in Austria
- Detailed analyses of riparian vegetation for study sites
- Identification of endangered riparian ecosystems in Austria by climate change
- Preparation of conservation measures for endangered riparian ecosystems

Results

The changes and risks of riparian vegetation due to climate change effect in Austria are illustrated. For **each ecoregion** is presented (1) the occurrence of floodplain features (2) the occurrence of biotope types and their threat and rareness and (3) the assessment of climate change effects for the four subscenarios: Impact effect and risk of considerable habitat loss.

The assessment different climate change scenarios at the Austrian level shows that within the prognoses there is high range of deviation. This is due to the wide range of possible change of driving forces for riparian vegetation. Within the four defined scenarios the driving forces “high morphodynamic” and “high frequency of flooding” are considered on the one hand with *increase* and on the other hand with *decrease* – the response of the vegetation can go into two directions: it can be encouraged or weakened. The scenario for riparian vegetation is defined with lower peaks of annual flood, less frequency of floods and in general dryer hydrologic conditions. This scenario effects many of the biotope types in a bad way. All over Austria for this case a regression is expected for 16 out of 22 riparian biotope types due to climate change. Only for one biotope type an encouragement due to climate change is expected. For maximum of 3 biotope types no change is forecasted and only for 1-2 biotope types the assessment of the impact effect is undetermined. In regions where these concerned biotopes are rare the risk of habitat loss is really high! Another scenario, assuming higher peaks of annual floods, a higher frequency of floods and also dryer hydrologic conditions, stands for an increase of morphodynamic processes in the river. This leads to a positive effect to many biotope types. All over Austria 8 biotope types are expected to benefit from this development, no biotope type is expected to be regressed. Anyway for 9-12 biotope types the trend is undetermined.

Within **Natura 2000 network** 33 sites in Austria with focus on riparian vegetation have been selected. In most of these sites the above mentioned endangered biotope types occur. For concrete analyses of specific Natura 2000 sites the Decision Support System is provided.

WP 4: Decision support systems (DSS)

Objectives

The decision support system (DSS) for riparian ecosystems in Austria should:

- Support development of risk analyses and management strategies for riparian ecosystems
- Assess different climate change scenarios
- Allow assessment on different spatial levels
- Show the risk of considerable habitats loss for Natura 2000 sites with riparian vegetation

Work proposed
Basics for the DSS are
1) the four climate change scenarios)
2) spatial information on different scales
3) Information on biotope types of Austria (Essl & Egger, 2010): List of biotope types of each ecoregion and their classification of rareness and threat in the ecoregion
4) Information on Natura 2000 sites in each ecoregion: List of biotope types of each site and list of floodplain features of each site
5) Information on floodplain features: List of biotope types in each floodplain feature

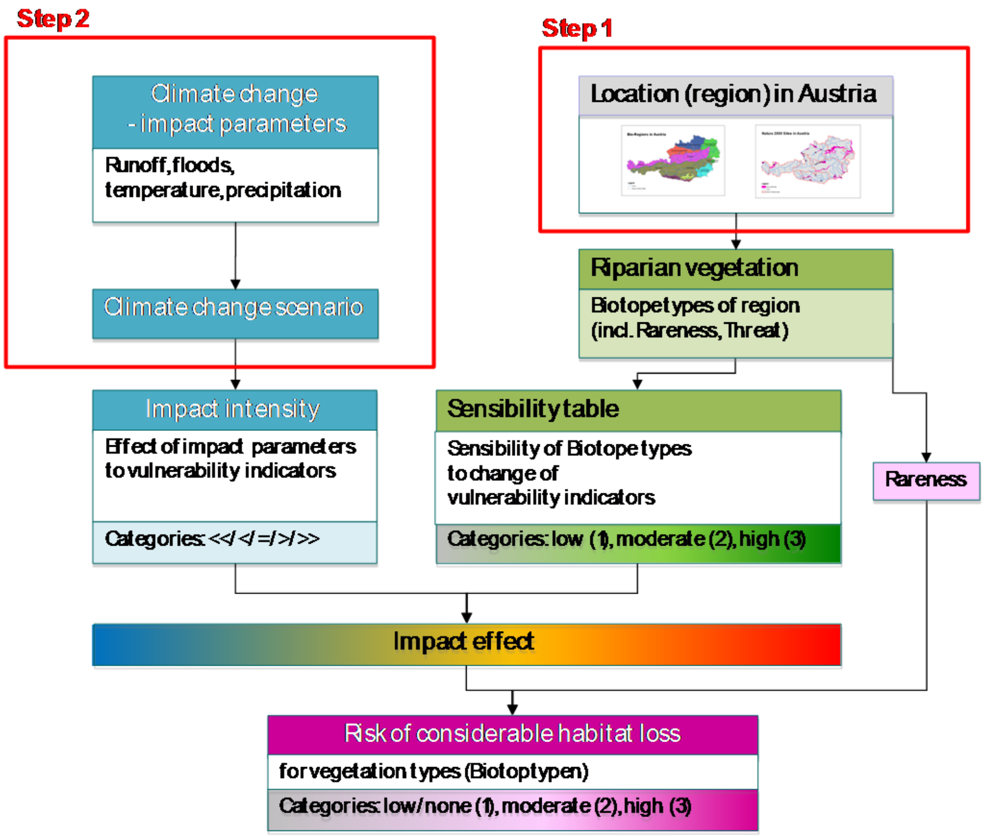
The DSS-program was used to assess the riparian vegetation changes on Austrian scale (see 0). In the part of method of this chapter it also described the concept of assessment. The concept has been implemented in the DSS-program. The DSS was programmed as VBA-application for Excel. The detailed description is given in the manual of the DSS.

Results
The DSS-program was used to assess the riparian vegetation changes on Austrian scale. In the part of method of this chapter it also described the concept of assessment. The concept has been implemented in the DSS-program. The DSS was programmed as VBA-application for Excel. The detailed description is given in the manual of the DSS.

Below is given an overview of the assessment steps.

The **Start-form** gives general information about the program:

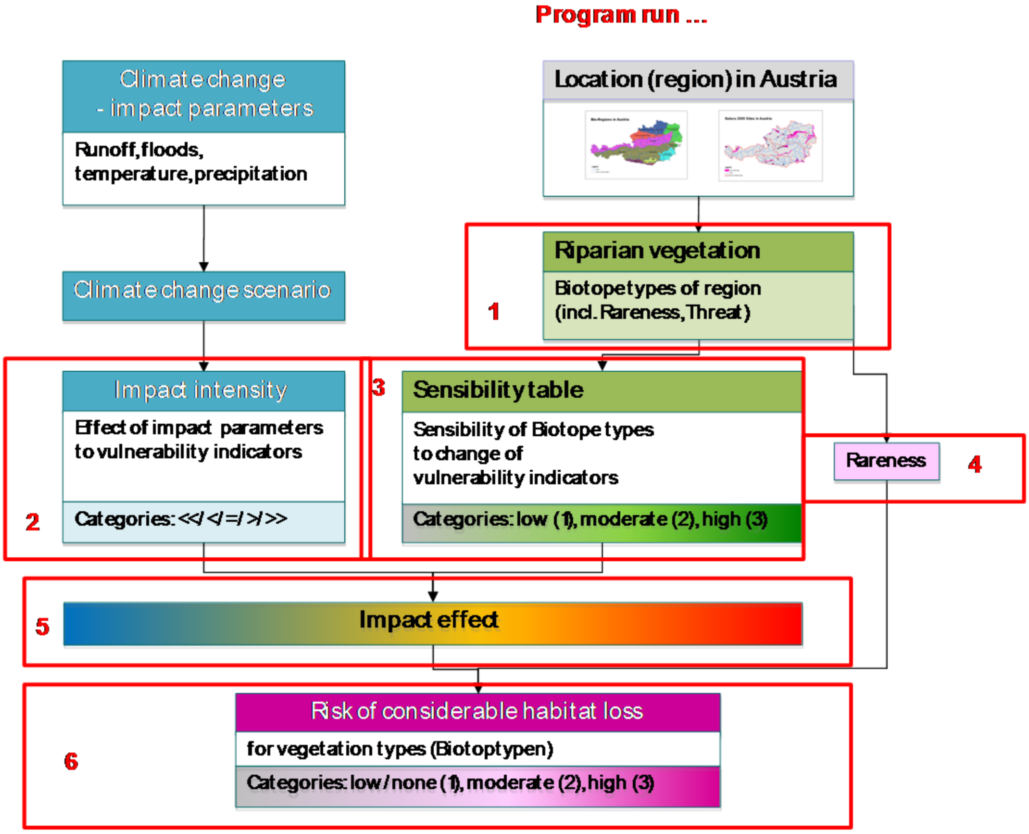
Input parameters from the user



The user has to select a location (Step 1) and a climate change scenario (Step 2).
In Step 1 a selection on three spatial levels is possible: (1) ecoregion (2) Natura 2000 site and (3) floodplain feature.
The four climate change scenarios in Step 2 are pre-defined (Subsenario 1-4, see Table 1: Hydrological sub scenarios).

Program run

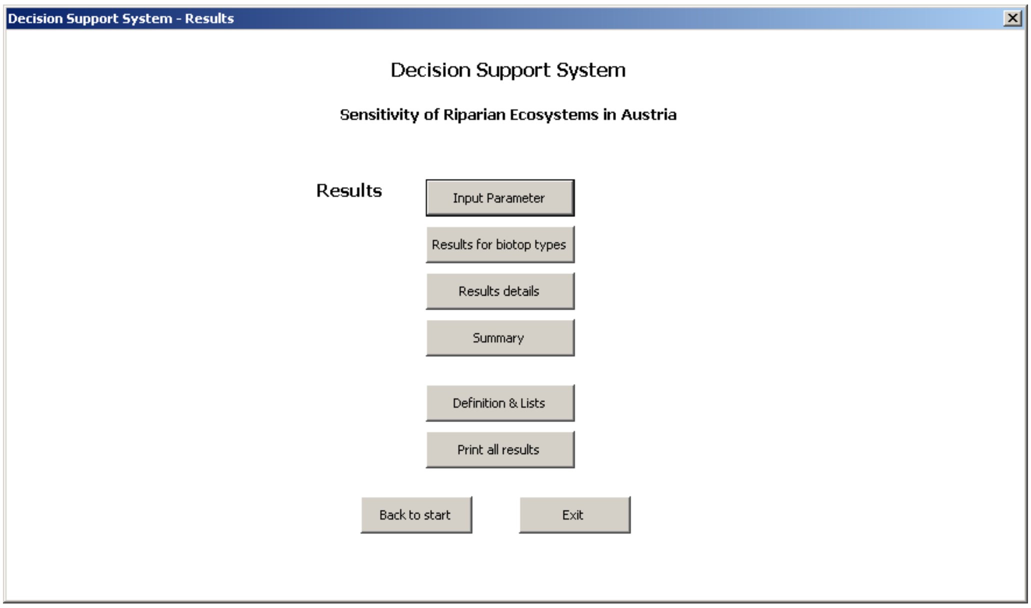
After setting the input parameters the program run is started.



Within the program run the following steps are done automatically:

- Select the relevant biotope types (basis: selection of spatial area in Step 1)
- Define impact intensity (basis: selection of spatial area in Step 2)
- Read out sensibility classes of selected biotope types (pre-defined table)
- Read out rareness of selected biotope types (pre-defined table)
- Define impact effect (as a function of biotope sensibility and impact intensity)
- Calculate the risk of considerable habitats loss (as a function of rareness and impact effect)

Results of DSS



As there are many results delivered by the program a menu is offered to the user. The following links (buttons) are available:

- List of all input parameters (from the user)
- Results for each biotope types
- Detailed results: sensibility indicators, impact intensity table, impact effect table
- Summary of results: List of biotope types, impact effect and risk of considerable habitats loss
- List of all predefined input tables
- Print buttons: All results and the lists
- Back button: Go back to Form 1, step 1
- Exit button: Quit program

3 Schlussfolgerungen und Empfehlungen

Identification of long- and short-term effects of climate change on riparian ecosystems
Climate change has impacts on hydrology and thus hydraulics and morphodynamics. However, as the results of the literature research show, the effects of climate change on hydrology are hard to predict. It is easier to determine the changes in mean temperature as they can be directly modeled with GCM´s (Global Climate Models) or RCM´s (Regional Climate Models). For changes in hydrology, the meteorological conditions have to be modeled and the changes in precipitation have to be determined. As precipitation is often affected by small scale processes, for which the coarse resolutions (time and space) of RCM´s and especially GCM´s are insufficient, significant uncertainties are present within the data. They further increase during the next step - the hydrological modelling.
To cope with these uncertainties multi model runs need to be done to evaluate the margin of deviation for each single parameter. In our study we have used a wide range of literature based on different models (only for SRES A1B) to determine the fluctuation range for several hydrological parameters. It turned out that the ranges of expected changes are smaller for mean values than for extremes.
The challenge in determining extreme events is that the forecasted changes based on GCM´s and RCM´s are more or less mean values and do not account for extremes in meteorological conditions. Extremes occur often on small spatial and temporal extents. Up to now, even with known discharge data over several decades, the extrapolated magnitudes of extreme flood peaks are subject of large uncertainties and trends of extreme events during the last century can not only be credited to climate change as there are also other causes (e.g. land use changes).
The riverine environment is not only influenced by the climate change, even more important might be the anthropogenic impacts. Especially the hydrology of a catchment is strongly affected by land use changes, the abstraction and retention of water and river engineering measures.

Hydrodynamic and vegetation model application
The impacts of vegetation on hydrodynamics and morphodynamics are manifold but the recruitment and the succession of vegetation is in return also based on the opportunities given by morphodynamics and hydraulics. This was observed at the side arm in **Kleblach**-Lind at the Upper Drau in Carinthia. Only once the gravel bar evolved to a less flooded area, vegetation started to develop.
As shown in the vegetation roughness sub-model, the vegetation effect on roughness is very important. Especially vegetation parameters like flexibility, height, width, stand density and projected area determine the magnitude of vegetation roughness. The distribution of vegetation patches in the river is also important as it alters the flow directions. The presented vegetation roughness model is therefore a valuable contribution to improve the hydrodynamic-numerical modelling of vegetated rivers. Side erosion is very important in the succession of vegetation as it is able to create new habitats by increasing the width of a river channel and by destruction of established plants. The changes in morphology, especially erosion, are the main cause of vegetation degradation and therefore have to be included in modelling riparian vegetation. In this study three different elevation models were used to model the period from 2003 to 2008. For future scenarios the morphodynamic changes are also very important to derive hydraulic parameters and to improve the succession of the vegetation. However, to predict mophodynamics for long periods using a simulation model is still challenging and time consuming.
The vegetation model can be improved by including results of sediment transport modelling. Therefore for each elevation model and discharge, sediment transport modelling is required, to evaluate areas with erosion and sedimentation. In connection with rooting depths or the maximum depth of sedimentation, where vegetation is still able to survive, both dependent on plant age and species, the destruction of vegetation might be approximated in a more realistic way.

Furthermore, the model does not consider the influence of woody debris in creating nursery sites for floodplain vegetation. Although all this might introduce uncertainties in the model results, the overall tendency of the vegetation development can be deemed as reliable.

Riparian ecosystems risk analyses for the case study sites

Observing the scenarios differences for the case study **Kleblach**, the riparian vegetation evolves along a two directional path: on the one hand one part of the area is remaining open (sand/gravel bars and pioneers). In case of floods with magnitude larger than in the reference period large areas are kept open, there the succession never establishes because, although recruitment is present, the seedlings are disturbed by annual floods and therefore recycled to initial phase. The rest of the area step by step develops in direction of floodplain forest, ultimately then, young most succession phases are lost and biodiversity decreases. Second development path is the one observed in the low floods scenarios (scenarios K1 und K3). In this case, open sand/gravel bank (pioneer) covers not more than 15%. The rest of the area is hardly disturbed by floods and the succession goes on from young pioneer phases also to the early successional woodland. Also in this case there is a loss of biodiversity.
In last instance, the conclusions from the Kleblach vegetation modelling and analysis have to keep into account the natural reference and the simulations endpoints of reference period and climate change scenarios. Kleblach baseline reference is characterized by an active turnover among the different vegetation patches composing a various landscape mosaic while, simulation endpoints return a quite static picture. In the reference period simulation, this is certainly due to the static morphology applied in the modelling while for the climate change scenarios, this condition is accentuated by the climate change induced ecosystem perturbations. Either way, it is clear that, when a river system like Kleblach is stabilized by bank protection, less side erosion occurs. As a consequence, morphodynamic processes are reduced and the ecosystems turnover is impaired, there is a loss of biodiversity and ultimately a decrease of ecological functionality. Furthermore important is the change of morphology and vegetation cover in relation to hydrology.
Hydrodynamic and vegetation models were also applied at the second case study site **Tauglgries**, a broaded river section of the Taugl river in Salzburg. Compared to the situation in Kleblach, the Tauglgries-site is affected by very high morphodynamic processes and bed load transport. Additionally side erosion plays an important role.
The main key conclusion that can be drawn from the scenarios simulated at Tauglgries, is about the recruitment conditions which are very harsh in consequence of both the high morphodynamic disturbance and the diffuse dryness. This combination of factors makes the seedling establishment very problematic since very few plots are suitable for recruitment. The vegetation recruitment could increase if the substrate sediments size would be reduced (more presence of fine sediments such sand), this in combination with the current abundant precipitation regime would likely create the right moisture conditions for seed germination. At the current status, most of the input sediment originates from the catchment area and it is quite coarse while the few fine sediment is originating from the bank erosion. It is not to be excluded that, in the long run, the contribution of fine sediment from the local erosion could reach a critical mass to significantly change the recruitment pattern.
Observing the scenarios differences, the change of recruitment area within the different scenarios (+/-25% change of annual flood) is not very significant and within the range of uncertainty of the model. Nevertheless, in case of increase of floods the recruitment area is lower. Although subject to uncertainties, such little decrease could however play a major role and its effects must not be underestimated. For some species in fact, this could be crucial because their area could be reduced below the minimal extension required to maintain a local population. Typical example of such species is the tamarisk (*Myricaria Germanica*) a species formerly abundant along the Alpine riparian ecosystems and nowadays highly endangered because of the loss of its habitat due to river regulation. Ultimately, for the well being of the Tauglgries riparian ecosystem, the bed load transport from the catchment area is very important and – especially regarding potential for recruitment – the maintenance of the side erosion must be kept.
The overall tendency of the observed results suggests that the scenarios which forecast an increase of maximum discharges would alter the reference landscape pattern by increasing the recycling of vegetation and not allowing the vegetation turnover because the young phases (pioneer, pioneer shrub) would hardly withstand to the strength of the floods. Climate change scenarios with peak discharge decrease would instead yield an opposite

result. The lack of relevant morphodynamic disturbance would allow an excessive quantity of vegetation to be recruited. Such excess would soon limit the open areas which are required for the establishment of pioneers and ultimately floodplain vegetation renewal.
The large differences between Kleblach and Tauglgries simulations can be explained with the as well large differences in the recruitment condition which occur in these two sites. At Kleblach, the simulated and field observed recruitment tendency shows that vegetation finds easily suitable conditions for establishing. On the other hand, at Tauglgries the vegetation hardly finds sites which are suitable for recruitment.
In addition a note shall be spent by underlying that the riparian processes acting on riparian vegetation are not only those included in the vegetation model. Further pivotal elements whose fate is bound to vegetation development are, for example, temperature and precipitation which regulate flower blooming, seeds germination and other metabolism functions. On the other hand, precipitation quantity, type (solid or liquid) and timing have as well an effect on soil moisture (and consequent plants physiological well being) and floods timing. These effects, although important where not kept into consideration because of lack of resources to produce a comprehensive model which can account also for the aforementioned phenomena. More importance has been therefore given to the hydraulically driven processes which are definitely more inherently bound to the riparian vegetation.
As a final statement for this section, the authors would like to stress one more time the importance of maintaining an active riparian vegetation turnover in the two study sites; if morphodynamic processes are reduced (i.e. by interrupting the sediment continuum and thus the sediment supply) these ecosystems will gradually be degraded and typical habitat elements such young pioneer phases will be lost. This process is not visible within a human sensible scale (i.e. 10 years or less) but they surely yield their effects within a tree generation time (30-50 year). If within this time, suitable recruitment condition will not be established and maintained, vegetation species will be strongly endangered or more likely extinct.

Riparian ecosystems risk analyses for Austria and Natura 2000 sites
The riparian vegetation of Austria has been analyzed based on biotope types (Essl & Egger, 2010). For these types guidelines are available for endangerment and rarity, where distinction in ecoregions is still made. From the total list of Austria, 22 biotope types representing the riparian vegetation have been selected. For these biotope types the driving forces have been defined and the sensibility of each classified. The impact effect has been assessed on different scales: The local scale of floodplain features, the regional scale of the ecoregions and the national scale of Austria. For conclusions about the *risk of considerable habitat loss* also the rareness of a biotope type within a region has been taken into account.
The assessment of different climate change scenarios at the Austrian level shows that within the prognoses there is high range of deviation. This is due to the wide range within the scenarios due to change of driving forces for riparian vegetation. Within the scenarios the driving forces “high morphodynamic” and “high frequency of flooding” are considered on the one hand with *increase* and on the other hand with *decrease* – the response of the vegetation can go into two directions: it can be encouraged or weakened. The “worst case" scenario (scenario 1) for riparian vegetation is defined with lower peaks of annual flood, less frequency of floods and in general dryer hydrologic conditions.
All over Austria for this worst case a regression is expected for 16 out of 22 riparian biotope types due to climate change. Only for one biotope type an encouragement due to climate change is expected. For maximum of 3 biotope types no change is forecasted and only for 1-2 biotope types the assessment of the impact effect is undetermined.
All over Austria for this case a regression is expected for 16 out of 22 riparian biotope types due to climate change. Only for one biotope type an encouragement due to climate change is expected. For maximum of 3 biotope types no change is forecasted and only for 1-2 biotope types the assessment of the impact effect is undetermined. In regions where these concerned biotopes are rare the risk of habitat loss is really high! Another scenario, assuming higher peaks of annual floods, a higher frequency of floods and also dryer hydrologic conditions, stands for an increase of morphodynamic processes in the river. This leads to a positive effect to many

biotope types. All over Austria 8 biotope types are expected to benefit from this development, no biotope type is expected to be regressed. Anyway for 9-12 biotope types the trend is undetermined.

The regressed biotope types of that “worst case" are:

- Altarm
- Grauerlenauwald
- Großröhricht an Fließgewässer über Feinsubstrat
- Kleinröhricht an Fließgewässer
- Mandelweiden-Korbweidengebüsch
- Pannonische und illyrische Auwiese
- Schlammufer der Fließgewässer mit Pioniervegetation
- Schotter- und Sandbank der Fließgewässer mit Pioniervegetation
- Schwarzerlen-Eschenauwald
- Schwarzpappelauwald
- Silberpappelauwald
- Vegetationslose Schotter- und Sandbank der Fließgewässer
- Vegetationsloses Schlammufer der Fließgewässer
- Weidenauwald
- Weidenpioniergebüsch
- Weiden-Tamarisken-Gebüsch

In regions where these biotopes are rare the risk of habitat loss is really high!
As stated above the scenarios have wide range. To illustrate this also the results of the “best case" scenario, assuming higher peaks of annual floods, a higher frequency of floods and also dryer hydrologic conditions (scenario 1) are shown. This scenario stands for an increase of morphodynamic processes in the river, which leads to a positive effect to many biotope types. All over Austria 8 biotope types are expected to benefit from this development, no biotope type is expected to be regressed. Anyway for 9-12 biotope types the trend is undetermined.
The biotope types that benefit from the “best case" scenario are:

- Grauerlenauwald
- Großröhricht an Fließgewässer über Grobsubstrat
- Lavendelweiden-Sanddorngebüsch
- Rotföhren-Trockenauwald
- Schotter- und Sandbank der Fließgewässer mit Pioniervegetation
- Schwarzpappelauwald
- Silberpappelauwald
- Vegetationslose Schotter- und Sandbank der Fließgewässer

<u>Natura 2000 sites</u>
Within the project Natura 2000 sites with focus on riparian vegetation have been selected. The final list includes 33 sites in Austria. In most of these sites the above mentioned endangered biotope types occur. For concrete analyses of specific Natura 2000 sites the Decision Support System is provided.

Decision support system (DSS) for riparian ecosystems in Austria
In the project a decision support system (DSS) to simulate the effect of climate change on riparian ecosystems in Austria was developed and programmed as well. The DSS is able to assess different climate change scenarios on different spatial levels. It includes information about Natura 2000 sites and the Austrian floodplain features. Results are offered in tables and lists. It was programmed as VBA-application for Excel with a user-friendly interface and self-explanatory handling. It delivers results within a few seconds. Additionally to the program-file a manual is delivered. Many of the program results are analyzed and discussed within this report.

C) Projektdetails

4 Methodik

Method of WP 2: Hydrodynamic, morphodynamics data and modelling

Climate change – impact parameters
Realistic climate scenarios are moving within range regarding to hydro-morphological impacts. Identification of impacts range on riparian vegetation will be based on the most realistic climate change scenario with four sub-scenarios development. This most realistic climate change scenario is REMO-UBA Temperature and Precipitation 2031-2060 scenario (GCM = ECHAM5; Scenario = A1B; Period =2031-2061; Season = JJA; see chapter 3.3.1). The four sub-scenarios are described using five parameters: annual runoff, peaks of annual floods, flood frequency, low flow periods and low flow discharge. For all sub-scenarios a decrease of annual runoff and low flow discharge on rivers is predicted in the literature. Furthermore, low flow periods are expected to increase for all sub-scenarios. Climate change parameters that can change in both directions are (1) the peaks of annual floods and (2) the flow frequency.

Derivation and analysis of climate change scenarios for Austria
The derivation and analysis of climate change scenarios for Austria were based on literature survey. The global changes of temperature and precipitation until 2100 in Central Europe were investigated based on outcomes of Global Circulation Models (GCMs). Then the effects of climate change on Austria were evaluated based on Regional Model outcomes, based on IPCC emission scenario A1B, which is considered to be a realistic scenario. Results of hydrological simulations based on these Regional Models were also investigated.

Quantification of climate change impacts on hydrology, hydraulics and morphodynamics
Considering the analyzed data, scenarios for changes in hydrological variables like annual runoff, peaks of annual floods, frequency of floods, change in low flow periods and seasonal runoff, have been derived and then the possible impacts on hydraulics and river morphology were defined.

Enhancement of hydrodynamic model by including a dynamic vegetation roughness sub model
The effects of vegetation on the roughness and in succession on the hydraulics and morphodynamics were investigated based on literature. The findings led to the development of a vegetation roughness sub model, which iteratively calculates the vegetation roughness. It was implemented in the hydrodynamic numerical model and verified with field observations.

Allocation of input parameters for the Vegetation model based on hydrodynamic – numerical modeling of the study sites Kleblach-Lind and Tauglgries
For this task, hydrodynamic models were set up, calibration was carried out and a variety of discharges were simulated. The results - flow velocity, water depth and bed shear stress respectively, were converted into grid files for being applicable in the vegetation model.

Determination of flood duration in Kleblach based on different geometries and hydrographs
For three digital elevation models (2003, 2005 and 2008) and two different hydrographs (wet and dry period) the duration of submergence was investigated for every computation cell. The area of submergence for a specific discharge was based on hydrodynamic modeling results.

Investigation of morphological changes at the study site Kleblach to demonstrate the opportunities of applying sediment transport models in the context of vegetation modeling

The integrated sediment transport model iSed (Tritthart et al., 2011) was run for an observed unsteady flow event. The bed level changes were evaluated. Combined with literature research (esp. within the topic of "decrease of anchoring stability of plants due to erosion of soil") the opportunities of sediment transport models in context with vegetation models were discussed.

Method of WP 3.1: Riparian vegetation changes at the study sites

Floodplain vegetation model concept

In order to quantify the climate change impacts on the riparian vegetation; a dynamic vegetation model has been applied whose main features are the simulation of floodplain vegetation spatial distribution over space and time (see Figure 9). The model concept states that vegetation will develop or be recycled in response to hydraulic driven inputs. The model makes use of spatial inputs (raster grids) and it is rule based.

The model is addressed as dynamic, because it takes different inputs for each simulated year and because the outputs of each model run are fed again to the model as input for the next iteration. In the model conceptualization, vegetation is represented as discrete development stages (succession phases) which belong to distinct development lines (succession series). This method was considered optimal for the transferability of results, because a species-to-species comparison is difficult, and these phases can be used to build the scheme of succession-retrogression pathways in any most of the river types of the Northern hemisphere. Therefore, the method is potentially transferable to different countries and climates. Basically, the succession phases show differences in the types of herbs or woody species dominant in a patch, in the habitat conditions (abiotic factors such us soil texture, organic content, distance to the groundwater, etc.) and in the plant development stage (age).

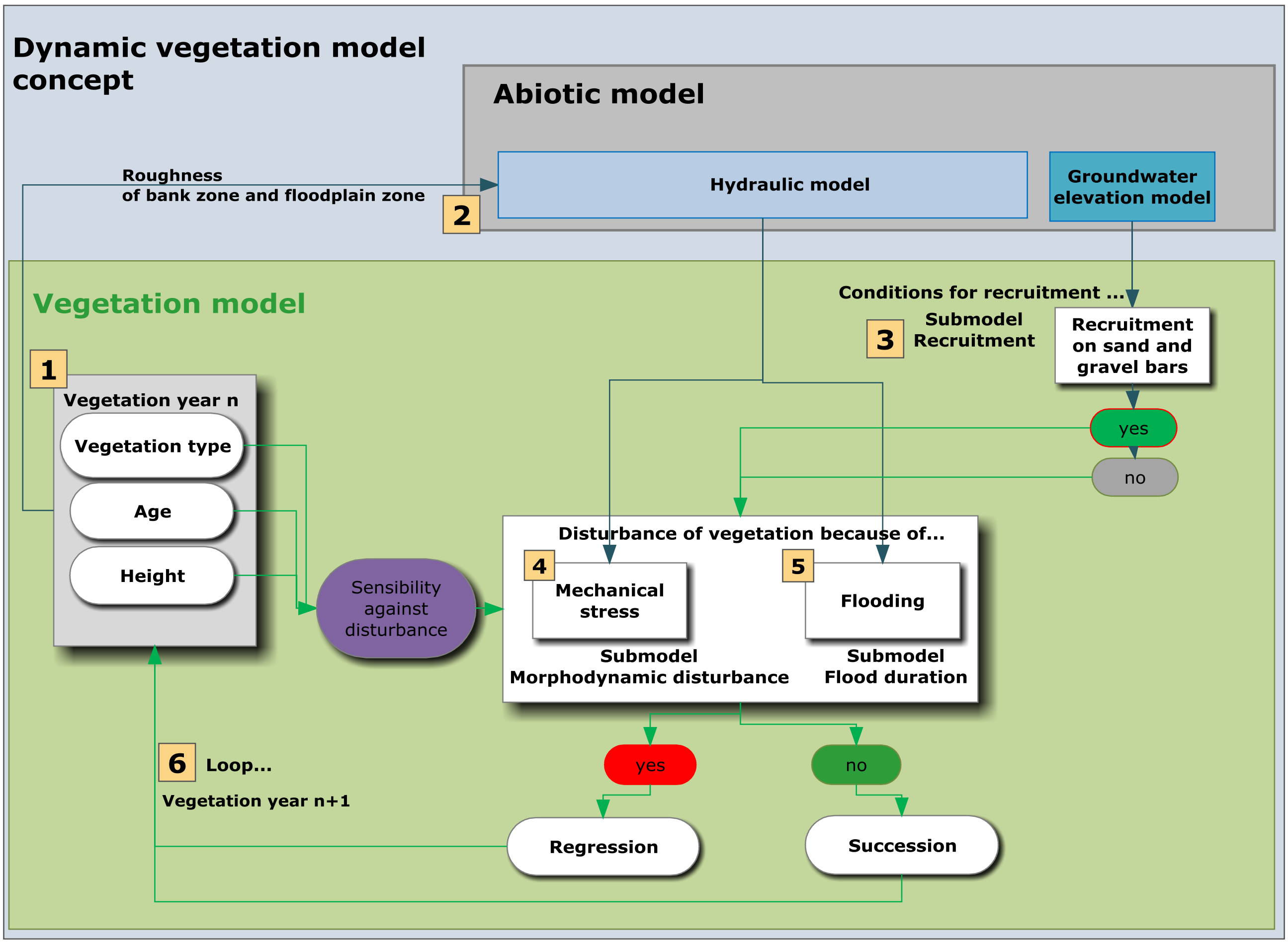


Figure 9: The concept of the dynamic vegetation model

Hydrology of reference period and climate change scenarios

For consideration of climate change scenarios in the dynamic vegetation model and for the two case study sites the information about effect of climate change on hydrology is used. Several hydrologic parameters are used to quantify the effect of climate change. For the case study simulation the following parameters were selected:

Peaks of annual floods: The climate change prognoses are in range between 25% increase and 25% decrease.

Decrease of runoff and **increase of low flow periods**: These parameters are summarized to forecast the change of "spring runoff", which is valued with the annual mean discharge from May and June. For all scenarios a decrease of the spring runoff is assumed.

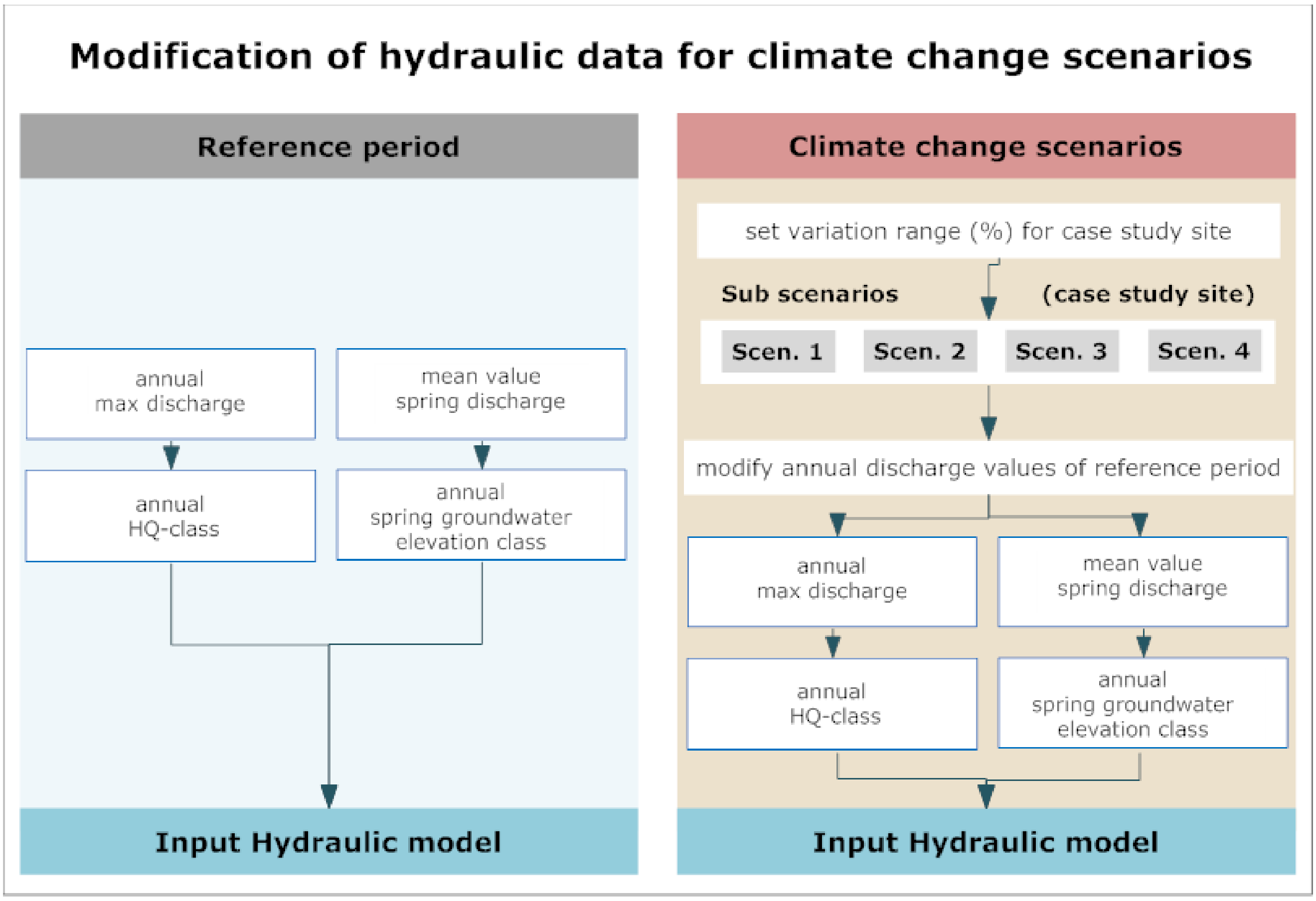


Figure 10: Scheme Modification of hydraulic data for climate change scenarios

The four climate change scenarios that have been selected are listed in Table 3. Based on these percentage variations the statistic hydrologic values have been modified. After that the modified values for the scenarios were summarized in classes like for the reference period. The class of each year leads to a specific raster map output from the hydraulic model that is further used as input for the vegetation model (see Figure 10). The raster map for the maximum shear stress is used to quantify the mechanical disturbance, the raster map for spring water elevation to simulate the recruitment conditions within the submodel "recruitment".

Table 3: Climate change scenarios for case study sites Kleblach and Tauglgries

Scenario Nr.	Long-Scen.Nr.	Short description	Scenario definition for Kleblach			Scenario definition for Tauglgries		
			Scen.-Nr.	Peaks of annual floods	Spring runoff (May & June)	Scen.-Nr.	Peaks of annual floods	Spring runoff (May & June)
1	A1BA	Dry and lower floods	Scen.-K1	Minus 25%	Minus 20 %	Scen.-T1	Minus 25%	Minus 10 %
2	A1BB	Dry and higher floods	Scen.-K2	Plus 25%	Minus 20 %	Scen.-T2	Plus 25%	Minus 10 %
3	A1BC	Very dry and lower floods	Scen.-K3	Minus 25%	Minus 35 %	Scen.-T3	Minus 25%	Minus 20 %
4	A1BD	Very dry and higher floods	Scen.-K4	Plus 25%	Minus 35 %	Scen.-T4	Plus 25%	Minus 20 %

Method of WP 3.2: Riparian vegetation changes on Austrian scale

The evaluation of effects of climate change on riparian vegetation is based on four different scales: (1) the national scale, (2) the 8 ecoregions of Austria (Sauberer & Grabherr, 1995), (3) the Natura 2000 sites of Austria and (4) the floodplain features (Schwarz & Lazowski 2011). As a result of this analysis the riparian ecosystems, which are under high risk of alteration due to climate change, are defined. This information is accompanied within Natura 2000 network, which allows identifying important conservation areas treated by climate change and further conservation measures. The concept of assessment of riparian vegetation changes on Austrian scale is illustrated in Figure 11.

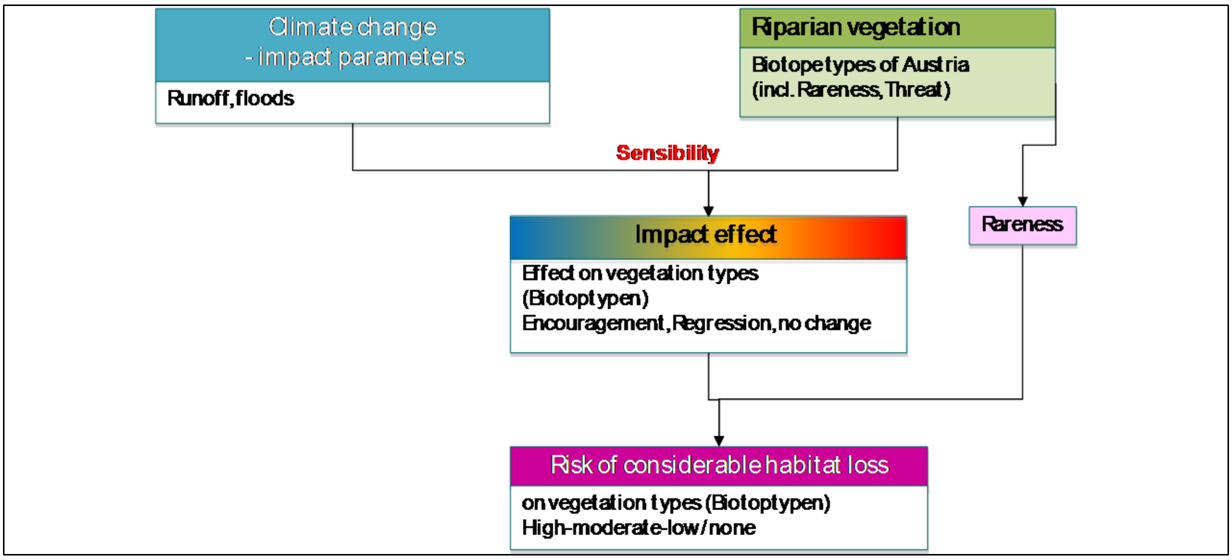


Figure 11: Overview of assessment process of riparian vegetation on Austrian scale

Method of WP 4: Decision support systems (DSS):

Basics for the DSS are

1. the four climate change scenarios
2. various spatial information:
    a. The 8 ecoregions of Austria (Sauberer & Grabherr, 1995)
    b. The Natural protected areas – Natura 2000 sites
    c. The floodplain features (Schwarz & Lazowski 2011)
3. Information on biotope types of Austria (Essl & Egger, 2010)
    a. List of biotope types of each ecoregion and
    b. their classification of rareness and threat in the ecoregion
4. Information on Natura 2000 sites in each ecoregion
    a. List of biotope types of each site and
    b. List of floodplain features of each site
5. Information on floodplain features
    a. List of biotope types in each floodplain feature

The DSS-program was used to assess the riparian vegetation changes on Austrian scale. In the part of method of this chapter it also described the concept of assessment. The concept of riparian assessment from WP 3.2 has been implemented in the DSS-program.

5 Arbeits und Zeitplan

Work Package	Contents	Month																			
		Okt.09	Nov.09	Dez.09	Jän.10	Mai.10	Jul.10	Aug.10	Sep.10	Okt.10	Nov.10	Dez.10	Jän.11	Feb.11	Mär.11	Apr.11	Mai.11	Jun.11	Jul.11	Aug.11	Sep.11
	Wissenschaftliche Aufgaben																				
WP 1	**Project coordination**																				
	Project management and monitoring	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Detailed project planning and review	X								X						X	X				
	Progress reports and cost statements									X									X	X	X
	Coordination of public relation activities		X	X						X	X								X	X	X
	Organization of workshops	X	X							X				X				X			X
	Project finalization																	X	X	X	X
WP 2	**Hydrodynamic, morphodynamics**																				
	Derivation and Analysis of climate change scenarios in Austria	X								X	X										
	model to study climate change effects on hydraulics, sediment transport and morphodynamic				X	X						X	X	X	X	X	X	X	X		
WP 3	**Riparian vegetation**																				
	Identification the changes in riparian vegetation in Austria							X	X												
	Detailed analyses of for riparian vegetation study sites					X	X														
	Identification of endangered riparian ecosystems in Austria by climate change											X	X	X							
	Preparation of conservation measures for endangered riparian ecosystems													X	X	X	X	X	X	X	
WP 4	**Decision support systems**																				
	Development of predictive scenarios for risk analyses and management for riparian ecosystems			X	X							X	X	X							
	Development of detailed management strategies for study sites regions													X	X						
	Development of DSS for riparian ecosystems in Austria			X											X	X	X	X	X	X	

List of project team meetings:

1. Workshop (Kick-Off): November 11th 2010, Klagenfurt
2. Workshop: January 29th 2010, Wien
3. Workshop: October 13th, Klagenfurt
4. Workshop: February 01st, Vienna
5. Workshop: June 14th, Vienna
6. Workshop: September 19th, Klagenfurt

6 Publikationen und Disseminierungsaktivitäten

During the project period the following dissemination of the Ripclima project can be possessed:

- Poster for the Klimatag 2010, 11. and 12. März 2010 in Wien
- Proceeding and presentation at the Klimatag 2011 in Vienna:
  G. Egger, H. Habersack, K. Angermann, E. Politti, M. Klösch, B. Blamauer, M. Tritthart: **Risk assessment and management of Riparian ecosystems in condition of climate change in Austria (RIPCLIMA).** Abstract Proceeding. 12. Österreichischer Klimatag. 21. and 22. September 2011, Wien
  At the 34th IAHR Congress the topic: "Refining parameterization of bar vegetation roughness based on in-situ-measurements of vegetation bending during flood events" was presented by a member of the project team (B. Blamauer).
- Proceeding for Euromech 2012 => Abstract accepted. Hydroecology: Reviewed paper Politti E., Egger G., Angermann K., Blamauer, B., Klösch, M, Tritthart, M., Habersack, H.: Evaluating Climate Change Impacts on Alpine Floodplain Vegetation. In Proc. Euromech Colloquium 523. Clermont-Ferrand, France, 15-17 June 2011
- Proceeding and presentation IAHR 34th Congress, Brisbane 2011
  B. Blamauer, M. Klösch, M. Tritthart, H. Habersack: **Refining parameterization of bar vegetation roughness based on in-situ-measurements of vegetation bending during flood events**. In: Engineers Australia (Ed.), Proceedings of the 34th IAHR World Congress, 3388-3395; ISBN: 978-0-85825-868-6 [34th IAHR World Congress, Brisbane, AUSTRALIA, JUN 26 - JUL 1, 2011]
- Proceeding for ISR-Berlin 2011
  Egger, G., Politti, E., H. Habersack, H., Kloesch, M., Ferreira, T.: **Using a Dynamic Vegetation Model as Follow-Up for River Restoration.** In Proc. ISRS 2011, 2nd Biennial Symposium of the International Society for River Science ISRS. Berlin, Germany, August 08-12, 2011.

Stakeholders' involvement

The involvement of stakeholders is recognized as an important activity in the project. The main stakeholders of the project are public authorities in charge of spatial planning, river basin management and nature protection as well as relevant national governmental bodies and secretariats of international environmental conventions. The project takes account of the perceptions of stakeholders of climate change impacts and adaptation and that why stakeholder dialogues were organized in the case studies. Several workshops have been organized with main stakeholders (water managers and nature conservationists) of the two case study sites. At this meeting the scientific results achieved in WP2 and WP3, as well as best options for further conservation and management activities in conditions of uncertainty of climate change have been presented and discussed.

List of stakeholder meetings

03.02.2011: Stakeholder-Meeting in Spittal a.d.Drau (case study Kleblach)

Stakholders: Thomas Friedl, Herbert Mandler, Werner Petutschnig (Abt. 8, Amt der Kärntner Landesregierung)

Project team: Gregory Egger, Helmut Habersack, Mario Klösch, Bernadette Blamauer

03.11.2010: Stakeholder-Meeting in Salzburg (case study Tauglgries)

Stakholders: G. Jaritz, G. Nowotny (Abt. 13, Amt der Salzburger Landesregierung)

Project team: Gregory Egger, Karoline Angermann

14.12.2010: Stakeholder-Meeting in Bad Vigaun (case study Tauglgries)

Stakholders: G. Jaritz, G. K. König (Abt. 13, Amt der Salzburger Landesregierung) u.o.

Project team: Gregory Egger, Karoline Angermann

26.09.2011: Stakeholder-Meeting in Salzburg (case study Tauglgries)

Stakholders: G. Jaritz, G. G. Nowotny, S. Stadler (Abt. 13, Amt der Salzburger Landesregierung) u.o.

Project team: Gregory Egger, Karoline Angermann

7 Literatur

Böhm, R. (2008): Harte und weiche Fakten zum Klimawandel – ein Überblick. In ÖWAV (Hrsg.): Auswirkungen des Klimawandels auf die österreichische Wasserwirtschaft, BMLFUW und ÖWAV, Wien.

Essl, F. & Egger, G. (2010): Lebensraumvielfalt in Österreich - Gefährdung und Handlungsbedarf - Zusammenschau der Roten Liste gefährdeter Biotoptypen Österreichs. Klagenfurt (Naturwissenschaftlicher Verein für Kärnten & Umweltbundesamt GmbH), 111 S.

Gobiet, A., Truhetz, H. (2008): Klimamodelle, Klimaszenarien und ihre Bedeutung für Österreich. In ÖWAV (Hrsg.): Auswirkungen des Klimawandels auf die österreichische Wasserwirtschaft, BMLFUW und ÖWAV, Wien.

Nachtnebel, H.-P. (2008): Auswirkung von möglichen Klimaänderungen auf die Hydrologie und Wasserwirtschaft in eineigen österreichischen Regionen. In ÖWAV: Auswirkungen des Klimawandels auf die österreichische Wasserwirtschaft, BMLFUW und ÖWAV, Wien.

Sauberer, N. & Grabherr G. (1995): Fachliche Grundlagen zur Umsetzung der FFH-Richtlinie, Schwerpunkt Lebensräume. Umweltbundesamt Report 115.

Schädler B., Frei C., Grebner D., Willi H.P., 2007: Grundlagen zum Klima. Wasser Energie Luft -99. Jahrgang, Heft 1, CH-5401 Baden, Seite 58-60

Schwarz, U. & Lazowski W. (2011): Aueninventar Österreich, Bericht zur bundesweiten Übersicht der Auenobjekte. Studie im Auftrag des Lebensministeriums, 52 S,

Tritthart, M., Schober, B., Habersack, H. 2011: Non-uniformity and layering in sediment transport modelling 1: flume simulations. Journal of Hydraulic Research Vol. 49, No.3 (2011), pp. 325-334