Publizierbarer Endbericht

Gilt für Studien aus der Programmlinie Forschung

A) Projektdaten

Allgemeines zum Projekt	
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KoordinatorIn/ ProjekteinreicherIn:	Universität für Bodenkultur (BOKU), Institut für Wald-, Umwelt- und Ressourcenpolitik
Kontaktperson Name:	Prof. Dr. Karl Hogl
Kontaktperson Adresse:	Feistmantelstr. 4, 1180 Wien
Kontaktperson Telefon:	+43-1 47654-4402
Kontaktperson E-Mail:	karl.hogl@boku.ac.at
Projekt- und KooperationspartnerIn (inkl. Bundesland):	Institut für Raumplanung, Umweltplanung und Bodenordnung (IRUB) Institut für Hydrologie und Wasserwirtschaft (HyWa) Institut für Wasserbau, Hydraulik und Fließgewässerforschung (IWA)
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B) Projektübersicht

1 Kurzfassung

Das Projekt RegioFlood zielt darauf ab, politikrelevante Erkenntnisse und Schlussfolgerungen in Bezug auf die Schaffung eines wirksamen regionalen Hochwasserrisikomanagements als Mittel zur Anpassung an den Klimawandel zu liefern. Das Projekt wendet einen neuen Ansatz für die integrierte Bewertung von Überflutungs- und Hochwasserabflussflächen an, bei dem Landnutzungsfaktoren, hydrologische und hydraulische Faktoren sowie politische und wirtschaftliche Faktoren integriert werden. Die empirischen Ergebnisse werden aus zwei regionalen Fallstudien abgeleitet, in denen die verschiedenen Optionen für ein regionales Hochwasserrisikomanagement in ausgewählten Einzugsgebieten aufgezeigt werden. Die Beteiligung der relevanten Akteure wurde durch die Organisation eines Stakeholder-Workshops in einer der ausgewählten Fallstudienregion gewährleistet.
Das Projekt RegioFlood hat durch die **Analyse von drei verschiedenen politischen Instrumenten** zur Förderung des regionalen Hochwasserrisikomanagements neue Erkenntnisse zur Steuerung des Hochwasserrisikos in Österreich gewonnen: Regulierungsinstrumente, Kooperationsinstrumente und finanzielle Ausgleichssysteme. Auf der Grundlage von Dokumentenanalysen, Experteninterviews und einer Online-Befragung von Hochwasserschutzverbänden haben wir verschiedene lokale und regionale Fallstudien (z.B. Altenmarkt, Mittersill, Unteres Unterinntal) durchgeführt, um das Verständnis für die Herausforderungen und Vorteile der jeweiligen Governance-Regime zu vertiefen. Unsere Fallstudien zeigen, dass (i) Regulierungsinstrumente im regionalen Hochwasserrisikomanagement wirksame Mittel sind, um die Baulandentwicklung in gefährdeten Gebieten zu verhindern und große Gebiete für den Hochwasserschutz zu sichern, insbesondere durch Maßnahmen, die darauf abzielen, mehr Raum für die Flüsse zu schaffen, einschließlich Hochwasserrückhalt und Hochwasserabfluss; (ii) Kooperationen in Form von Hochwasserschutzverbänden sind etablierte Instrumente der interkommunalen Zusammenarbeit in der Wasserwirtschaft, die den Mitgliedern eine Plattform für die gemeinsame Interessenvertretung bieten und die gemeinsame Verwirklichung, Finanzierung und Aufrechterhaltung von Hochwasserschutzinfrastruktur ermöglichen; (iii) Ausgleichs- und Belastungsmechanismen sind entscheidende wirtschaftliche Rahmenbedingungen für die Umsetzung regionaler Hochwasserschutzmaßnahmen, wobei eine gerechte Lastenverteilung nach dem Nutznießer- oder Solidaritätsprinzip die Voraussetzung für eine erfolgreiche Umsetzung ist.
Ferner haben wir eine **integrative Methodik** entwickelt, um die Umsetzung **zukunftsorientierter Ansätze im Hochwasserrisikomanagement auf regionaler Ebene** zu unterstützen. Die RegioFEM ist eine neuartige Methode zur Unterstützung eines zukunftsorientierten Hochwasserrisikomanagements auf der Ebene von Flussabschnitten und (Teil-) Einzugsgebieten. Die RegioFEM integriert die quantitativen und qualitativen Forschungsmethoden aus den Bereichen Hydrologie, Wasserbau, Raumplanung und Politikwissenschaft, um die dynamischen Veränderungen des Hochwasserrisikos unter Berücksichtigung der geplanten Hochwasserschutzmaßnahmen, der zu erwarteten Siedlungs- und Infrastrukturentwicklung und den klimabedingten Änderungen im Hochwasserabfluss zu bewerten. Eine besondere Stärke der RegioFEM ist ihr explizit zukunftsorientierter Ansatz. Durch die Einbeziehung zukünftig geplanter Hochwasserschutzmaßnahmen und der zu erwarteten Siedlungs- und Infrastrukturentwicklung in die hydrodynamisch-numerische Modellierung der RegioFEM können Entscheidungsträger berücksichtigen, dass Investitionen in Hochwasserschutz-Infrastrukturen und auch Planungsentscheidungen (z.B. die Ausweisung von Bauland in hochwassergefährdeten Gebieten)

tiefgreifende und langfristige Konsequenzen für künftige Veränderungen der Hochwassergefahr und des Hochwasserrisikos auf regionaler und lokaler Ebene haben.
Die RegioFEM betrachtet die verschiedenen Treiber des Hochwasserrisikos einschließlich des Klimawandels als Informationsgrundlage für die Entwicklung vorausschauender Anpassungsmaßnahmen. Der einzugsgebietsorientierte Ansatz der RegioFEM unterstützt Entscheidungs- und Konsensfindungsprozesse im regionalen Hochwassermanagement, bei denen die Wechselbeziehungen zwischen Ober- und Unterliegern berücksichtigt werden müssen. Durch die Abgrenzung von Planungsgebieten anhand von hydrologischen/ hydraulischen oder Flächennutzungsparametern verwendet die RegioFEM als Ausgangspunkt für die Bewertung eine biophysikalische und keine politisch-administrative Perspektive. Sie bietet damit eine Grundlage für die Verbesserung der „räumlichen Anpassung“ des politischen Handlungsfeldes im regionalen Hochwasserrisikomanagement.

2 Executive Summary

RegioFlood aims at providing policy-relevant insights and conclusions regarding the establishment of an effective regional floodplain management as a means of climate change adaptation. The project applies a novel approach for floodplain evaluation integrating political parameters, land use parameters, hydrological and hydraulic parameters and economic parameters. The empirical results are derived from the comparison of different options for a regional floodplain management in two selected catchment areas as regional case studies. The involvement of relevant stakeholders was guaranteed by organizing a stakeholder workshop in one of the selected case study regions.
The project RegioFlood has generated novel insights into Austria’s flood risk governance by analysing three different policy instruments to promote regional floodplain management: regulatory instruments, cooperative instruments and financial compensation schemes. Based on document analysis, expert interviews and an online survey among water management boards we conducted several local and regional case studies (e.g. Altenmarkt, Mittersill, Unteres Unterinntal) to deepen our understanding of the challenges and benefits of the respective governance arrangements. Our case studies show that (i) regulatory instruments in regional floodplain management are effective ways to prevent the encroachment of settlements into hazard areas and to secure large areas for flood protection, specifically measures aiming to provide more room for the rivers, including flood retention and flood runoff; (ii) upstream-downstream cooperations in the form of flood protection associations are well-established instruments of inter-municipal cooperation in water management, that provide members a platform for the common representation of interests, and enable the joint realization, financing and maintenance of flood protection infrastructure; (iii) compensation and burden-mechanisms are decisive economic framework conditions for the realization of regional flood protection measures, with a fair distribution of burdens according to the beneficiary-pays or solidarity principle is the prerequisite for successful implementation.
Furthermore, we developed an integrative methodology to support the implementation of future-oriented approaches in flood risk management at the regional level. The **RegioFEM** - as the methodology was finally labelled to account for the regional dimension of the assessment - is a novel method to support future-oriented flood risk management at the scale of river stretches and (sub)catchments. The RegioFEM integrates the quantitative and qualitative research methods from the fields of hydrology, hydraulic engineering, spatial planning and political science to assess the dynamic changes in flood risk

in consideration of projected flood protection measures, expected settlement and infrastructure development and the likely climate-induced changes in flood runoff.
A particular strength of the RegioFEM concerns its explicitly future-oriented approach. By integrating projected flood protection measures and expected land and infrastructure development into the hydrodynamic-numerical modelling, the RegioFEM allows decision makers to account for the fact that investments in (flood defence) infrastructure but also planning decisions (e.g. to zone building land in flood-prone areas) have profound and long-term consequences for future changes in flood hazard and flood risk at regional and local level.
The RegioFEM considers the different drivers of flood risk change (including climate change) to provide an information basis for developing anticipatory adaptation measures. The RegioFEM's catchment-oriented approach supports regional flood management decisions that take into account the upstream-downstream interrelations of river riparians. By delineating planning areas on the basis of hydrologic/hydraulic or land use parameters, the RegioFEM applies a bio-physical rather than an administrative-judicial perspective as a starting point for the assessment. It thus provides a basis for improving the "spatial fit" for the political sphere of action in regional flood risk management.

3 Hintergrund und Zielsetzung

Due to their capacity to store water and to reduce peak flows, and thus alleviate downstream flooding, floodplains can significantly contribute towards climate change adaptation in flood-prone regions. Accordingly, maintaining or restoring river floodplains plays a key role in the integrated management of flood risks, as prominently outlined in the EU Floods Directive (2007/60/EC) and highlighted in the EU policy document on Natural Water Retention Measures. Fostering natural water retention is understood as both i) an effective course of action to reduce the impact of floods as well as ii) a robust and flexible measure to account for the likely albeit uncertain impacts of climate change on future flooding.
The regulating function of river floodplains as areas of flood storage and water retention, however, is in immediate conflict with competing claims for land use, in particular agricultural production and settlement use. Floodplains have always attracted agricultural and urban development due to their low slope, high soil fertility, and proximity to water. Consequently, many floodplains have been cut off from the river and worldwide around 50 % of the wetland surface is estimated to be lost, while in much of Europe this percentage is even higher.
Preserving and restoring river floodplains is therefore seen as a central element of adaptive flood risk management. For measures of natural water retention to meet their intended aims they are, however, to be "carried out in a coordinated way throughout a catchment" (EU Commission, 2011). As floods do not stop at administrative borders, structural flood protection measures (e.g. dykes) and land development in floodplains of upstream communities increase the flood risk in downstream communities. Coordination of upstream-downstream relations calls for river basin or catchment-based approaches, as advocated by the EU Floods Directive. Despite policy advances, such approaches are as yet only partially reflected in the Austrian legal and institutional frameworks. The Austrian Strategy for Adaptation to Climate Change accordingly recommends taking action on the "promotion of inter-municipal cooperation for the protection of large-scale ´solidarity´ areas for flood retention and hazard prevention" (BMLFUW, 2012: 118), and further calls for the introduction of compensation mechanisms and risk transfer models between municipalities or bodies under public law (e.g. water cooperatives or water boards) for the compensation of mutual land.

Against this background RegioFlood investigated the opportunities and constraints of establishing mechanisms of risk transfer for regional floodplain management under the conditions of climate and land use change by focusing on the integration of knowledge from different scientific disciplines and stakeholders. Furthermore, RegioFlood strived to advance the existing FEM-method (Floodplain Evaluation Matrix) to provide a new decision-support tool for policy-makers and stakeholders to assess the effectiveness of floodplains for flood protection. The FEM-Method, which has been applied for evaluating compensation strategies, was extended in order to account for complex relationships and interactions between do*w*nstream and upstream municipalities, by integrating risk transfer mechanisms, land use developments and population dynamics.

Based on the development of a "RegioFEM" method the general objective of the project RegioFlood was to provide policy-relevant insights and conclusions regarding the establishment of an effective regional floodplain management, also as a measure for climate change adaptation. More specifically the project aimed at:

- assessing the effectiveness of floodplains within catchments or along river reaches according to their flood (risk) mitigation effects in downstream municipalities under current conditions and future climate change scenarios;
- evaluating the availability of land for restoring river floodplains considering current land uses as well as future land use options;
- establishing a link between the flood risk of upstream and downstream regions using the damage potential as an indicator for monetizing the potential benefits of floodplains for reducing flood risk in downstream regions;
- determining which types of institutional arrangements and policy instruments, legally binding or voluntary, are suitable mechanisms of risk transfer between upstream and downstream regions;
- integrating hydrological, hydraulic, land use and institutional analysis of floodplain dynamics for developing an effective regional floodplain management.

4 Projektinhalt und Ergebnis(se)

The project consisted of six WPs, five of which were concerned with research and the sixth with organizing a stakeholder workshop in the selected case region. The six WPs and the activities performed hereunder can be summarized as follows:

Assessment of risk transfer models and compensation schemes (WP1)

In WP1 we deepened our understanding of the three different governance arrangements (regulatory, cooperative and financial instruments) towards regional floodplain management. A literature-based analytical framework was set up as a point of departure to map and analyze the Austrian landscape of regional floodplain governance arrangements. The framework combines the following three dimensions of inquiry: (i) regulative instruments in regional floodplain management; (ii) cooperations between upstream and downstream riparians; and (iii) mechanisms of financial compensation and burden-sharing. Based on the analytical framework we conducted in-depth case studies of different approaches in regional floodplain management based on qualitative research methods.

ad i) Regulatory instruments in regional floodplain management are effective ways to prevent the encroachment of settlements into hazard areas and to secure large-scale areas for flood retention and

flood runoff. In line with the EU-mandated catchment-orientation in flood risk management and the prioritisation of flood retention over structural flood defence, novel regulatory instruments in water management and spatial planning emerged in Austria.
We investigated the following cases of regulatory instruments in regional floodplain management: (i) Blue-Zone Rheintal (Blauzone Rheintal) in Vorarlberg; (ii) Regional Water Management Programme (Wasserwirtschaftliches Regionalprogramm) in Lower Austria. The focus of inquiry included the instruments' genesis, the spatial extent and the spatial delineation of the retention/runoff areas as well as the land use regulations imposed by the regulatory instrument.

- Löschner L, Seher W, Nordbeck R, Kopf, M (2019): Blauzone Rheintal: a regional planning instrument for future-oriented flood management in a dynamic risk environment. In: Hartmann T, Slavíková L, McCarthy S (Eds.): Nature-Based Flood Risk Management on Private Land. Springer, pp. 141-154.

ad ii) *Upstream-downstream cooperations* are an integral part of catchment-oriented approaches in flood risk management. Accordingly, the Austrian Water Act 1959 (Article 87) permits the establishment of formalized flood risk co-operations under public law, mainly between administrative bodies (i.e. municipalities) and those in charge of maintaining public traffic routes (such as the Austrian Railways). In addition to these cooperations of (predominately) state actors, the Austrian Water Act (Article 78 ff.) also regulates the establishment of flood protection cooperatives including nonstate actors, such as private landowners, who have a stake in or are affected by flood protection measures.
We investigated two different types (formalized/non-formalized) of upstream-downstream cooperation: (i) the Lower Inn Valley (Unteres Unterinntal) in Tirol; (ii) the Krottenbach in Lower Austria. The case study analysis comprised the structural dimension of the cooperation (i.a. aims, setting, partners involved) and the procedural dimension of the cooperation (i.a. coordination, resource distribution).
In addition to the activities outlined in the project proposal, we conducted a nation-wide online survey among the 168 water associations in Austria. We gained the following insights from the survey: (i) the establishment of water associations is predominately hazard-driven, (ii) water associations vary significantly in size and concerning the number of members; (iii) water associations pursue a wide range aims and motives (e.g. construction of flood defense measures, river maintenance, emergency planning); (iv) water associations exhibit diverse investment activities and apply a wide range of cost allocation mechanisms; and (v) facilitating factors were easily identified, confirming that mainly successful/active cooperations participated in the online survey.

- W. Seher and L. Löschner (2016): Balancing upstream–downstream interests in flood risk management: experiences from a catchment-based approach in Austria. Journal of Flood Risk Management.
- Nordbeck R, Löschner L, Scherhaufer P, et al (2018) Hochwasserschutzverbände als Instrument der interkommunalen Kooperation im Hochwasserrisikomanagement. Österreichische Wasser- und Abfallwirtschaft, 70: 316–327.

ad iii) Financial compensation schemes: According to Heiland (2002: 316) two different mechanisms can be used to incorporate economic principles into burden-sharing arrangements of financing flood protection: negotiations or funds. In the case of negotiations, beneficiaries in downstream municipalities negotiate directly with upstream landowners about offers to pay for flood protection measures. In the fund model, potential beneficiaries set up a funding trust or financial pool to which they contribute

financially and whose capital is then used to finance precautionary measures. This requires a functioning co-operation structure whose partners are legally and financially capable of payments which is accompanied by processes of moderation during the initial phase to establish the funding structure.
We investigated two different forms of financial burden-sharing in Austria. On the one hand we see cases where the cooperation is organized as water cooperative (Wassergenossenschaft) and the financial compensation scheme is based on the beneficiary-pays-principle. The cases of Altenmarkt and Mittersill are characteristic for this model. On the other hand, we see cases where the organizational structure is a regional water board (Wasserverband) and where the financing is typically based on the solidarity principle, such as the water board in the Lower Inn Valley or the AG Krottenbach mentioned above.

- Löschner, L., Nordbeck, R., Schindelegger, A., & Seher, W. (2019). Compensating Flood Retention on Private Land in Austria: Towards Polycentric Governance in Flood Risk Management? Landscape Architecture Frontiers, 7(3), 32-45. https://doi.org/10.15302/ J-LAF-1-020004

Assessment of land use and land use development (WP2)

As part of the case study analysis of selected river reaches in WP2 we analysed and mapped the prevailing land uses and assessed potential future land use developments (until the year 2030) in flooding areas with 30-, 100- and 300 years recurrence intervals. With regard to the current state of land uses the GIS based assessment determined the spatial distribution of settlements, infrastructure and open land in the floodplain. The availability of land for flood storage zones was checked against the likely future land developments in the selected river reaches based on census and land use data, demographic projections (provided by the Austrian Conference on Spatial Planning) and the analysis of spatial planning documents. The assessment of current land use and future land developments in river reaches provided a key input for identifying potential land use conflicts related to flood protection and flood risk management in the study areas.
WP2 was developed within the framework of integrated RegioFEM methodology (see WP5). The **assessment of the current flooding and flood risk** situation in the selected planning area (i.e. inventory) a three-part assessment consisting of a total of eight parameters in three categories: (i) flood hazard, (ii) hazard exposure and (iii) damage potential. The assessment is conducted for the entire river reach (including the respective sections) for different return periods, including high probability (e.g. 1/30-year), medium probability (e.g. 1/100-year) and low probability floods (e.g. 1/300-year). The objective of the inventory is to identify significant flood retention and runoff areas and to provide an overview of the spatial distribution of flood-exposed and vulnerable land uses in the study region. It thus offers the baseline for comparing the effects of future developments in the case study region and helps to identify specific areas in need of additional/complementary flood risk management measures.
For assessing the **spatial distribution of flood hazard exposure** in the river reach and the respective sections, we use the following four parameters: (i) “number of affected buildings in hazard areas” and (ii) “affected building land”, (iii) affected agricultural areas” and (iv) “number of affected plots”. The first three parameters indicate different types of elements at risk of flooding, i.e. buildings and vulnerable land uses. The fourth parameter, on the other hand, is a (simplified) measure for the structure of land (and land ownership) in the flood-prone areas.
For all four parameters, a Geographic Information System (e.g. ArcGIS, QGIS) is used to intersect the flooding area with geo-referenced land use data, such as the digital cadastral map (DKM) and the digital local land use plan. The DKM provides information on the plot and building size and the types of land

uses (e.g. agricultural land, forest, settlements). In the case of Austria, the DKM can be accessed online at the respective State GIS-repositories; alternatively GIS-compatible shapefiles may be obtained as through the State Planning Offices or the Federal Office of Metrology and Surveying (BEV). While the DKM is generally up-to-date, it is advisable to validate the current land development with aerial photographs.

As opposed to other geo-referenced, but not publicly available data sources (such as the national building register - AGWR), the DKM does not contain information on the types of buildings. It is therefore necessary to intersect the DKM with the digital municipal land use plans, which can also be accessed online or through the State Spatial Planning Departments. Based on the zoning areas the affected buildings can be classified into different categories (e.g. residential, commercial or agricultural) to assess their potential damage according to the different design floods.

To account for **future land development in the riparian areas** we reviewed the municipal land development plans and digitalized in GIS those areas where land development (zoning of building land) shall take place within the next 10-15 years (ca. until 2030).

For the identification of potential land use conflicts, projected flood protection measures are checked with expected land development in the case study regions.

The model runs indicate that future developments will have significant positive and negative effects on the flooding situation in the case study region. For both study regions, the assessments show that flood protection measures have significant effect on downstream flood hazard exposure. Given restrictive land development policies in this region, settlement development, has a limited effect on flood hazard potential (WP3) and flood risk (WP4). By taking into account current land uses and expected settlement and infrastructure development in the study areas, it provides a key input for the assessment of future changes in flood risk. The findings thus contribute towards (i) a better understanding of the interrelation between flood protection schemes and floodplain development and (ii) support the development of compensation schemes between the providers and beneficiaries of flood protection measures.

The following publications describe and discuss the findings of the exposure assessment within the wider scope of the RegioFEM method (see WP5):

- Löschner et al. (under review): RegioFEM: a novel method for future-oriented flood risk management at the regional scale (Part I). Submitted for publication in: Journal of Flood Risk Management
- Eder et al. (under review): RegioFEM: supporting future-oriented flood risk management in an Austrian river reach (Part II). Submitted for publication in: Journal of Flood Risk Management
- Wesemann et al. (under review): Regionale Entwicklung des Hochwasserrisikos unter Berücksichtigung zukünftiger Entwicklungen / Regional development of flood risk under consideration of future development. Submitted for publication in: Hydrologie und Wasserbewirtschaftung (HyWa)

Modelling of hydraulic and hydrological hazard parameters for different scenarios (WP3)

In the framework of WP3 hydrological and hydraulic parameters in regard to different future scenarios are derived by using hydrodynamic-numerical 2D-models (hydro_as-2d/SMS) for two selected case study sites. The assessment of floodplain effectiveness of the status quo (SQ) is performed in terms of hydrological (flood wave peak reduction and flood wave translation) and hydraulic (water level changes) parameters. It thus offers the baseline for comparing the effects of future developments in the case study regions. Considering these findings as well as the input from WP1, WP2 and WP4, selected future scenarios including climate change, land use changes, population growth and flood mitigation measures

were investigated. The hydrological and hydraulic results of these assessments form the basis for WP4 (risk assessment) and WP5 (development of extended FEM method - RegioFEM), in order to display the complexity of upstream-downstream relations in regard to flood water storage and runoff as well as its compensation.

Methodological framework

For both case study sites, it was necessary to create six different models to investigate the status quo and future developments in the study areas and assess their consequences. One of them is the current state or status quo model (SQ), which represents the investigation area in its current state. Four models were developed for future scenarios, where expected/planned future developments were anticipated in the study region. Two of them (PD1, PD2) differ only in reference to the geometry, compared with the status quo model (SQ). They consider the ongoing development in the project areas in terms of land use changes, population growth, flood mitigation measures and infrastructure projects. The other two models (PD1+CC, PD2+CC) consider the same developments as PD1 and PD2 as well as changes in the hydrological input data due to climatic changes. To account for potential climate related impacts on flood runoff, we factored in a 10 % climate change allowance to the existing flood discharge levels entering the hydraulic models (PD1+CC, PD2+CC). This climate factor corresponds to the upper end of the possible range of changes in extreme flows and thus presents a worst-case assumption of possible climate change-induced impacts on future flood hazard in Austria (Blöschl et al., 2018). It can be mentioned that a detailed assessment of possible changes in flood runoff was conducted for the study region “Raab”, utilising climate projections from 11 different Regional Climate Models as an input into a calibrated hydrological model. The simulations showed a large spread of possible changes of extreme flood values towards an increase, but also towards a decrease (Herrnegger et al., 2018). In light of these prevailing uncertainties, it was decided to use the above mentioned 10 % climate change allowance. Further, a river channel model (FS – Flussschlauchmodell) was created to determine the retention effects of the river channel. In addition, this model was used for a hypothetical assumption, which assumes the loss of all floodplains in the investigation area. This model is needed for the inventory of the river reach, which is part of the RegioFEM. For all models, events with different return periods (HQ30, HQ100, HQ300) were simulated and assessed.

For both case study sites, the calibration of the current state model (SQ) was conducted based on the official hazard maps. The official flood areas were aligned with the modelled ones; this was done in close cooperation with the responsible department of the local authorities, in order to clarify any deviations that were arising. The Strickler coefficients kst for the roughness of the adapted models were transferred from the existing models. These values were calibrated before; hence they were not changed during this project.

Case study - Raab

The model runs indicate that future developments will have significant positive and negative effects on the flooding situation in the case study region “Raab” as illustrated in Table 1 for the entire river reach given a 100-year design flood:

- Reduction of the inundation area for PD1 and PD2 due to the flood protection measures
- Increase of the inundation area for PD1+CC and PD2+CC, because of the overtopping of flood protection measures due to the increased discharges
- Rise of the flood peak reduction for all future developments, mainly caused by a new implemented road and their dams, which are expected to create retention basin-like effects
- Similar flood wave translation for PD1 and PD2

- Acceleration of the flood wave peak in the future scenarios PD1+CC and PD2+CC
- Without floodplains the water level will increase by 0.5 m in the river channel at the end of the study area; there is almost no peak reduction and the flood wave is expected to accelerate by 8.75 h

Parameters		Inventory		Future changes			
		SQ	FS	PD1	PD2	PD1+CC	PD2+CC
Hydrological/Hydraulic	Inundation area	1.950 ha	-	1818 ha	1777 ha	1945 ha	1908 ha
	Flood peak reduction	28 m^3s^{-1}	1 m^3s^{-1}	31 m^3s^{-1}	30 m^3s^{-1}	35 m^3s^{-1}	35 m^3s^{-1}
	Flood wave translation	13.75 h	5 h	13.75 h	13.5 h	12.25 h	12 h
	water level change	-	0.5 m	-	-	-	-

Table 1: Assessment of the hydrological (peak reduction, wave translation) and hydraulic (inundation area, water level change) FEM-parameters for a HQ100 – case study "Raab"

Case study - Salzach

The model runs indicate that future developments will have significant positive and negative effects on the flooding situation in the case study region "Salzach" as illustrated in Table 2 for the entire river reach given a 100-year design flood:

- Significant reduction of the inundation area for PD1 and PD2 due to the flood protection measures (especially effects of retention basins)
- Increase of the inundation area for PD1+CC and PD2+CC, because of the overtopping of flood protection measures due to the increased discharges
- Similar flood peak reduction for future developments SQ, PD1 and PD2
- Rise of the flood peak reduction for PD1+CC and PD2+CC
- Similar flood wave translation for all future developments
- Without floodplains the water level will increase by 1.38 m in the river channel at the end of the study area; there is almost no peak reduction and the flood wave is expected to accelerate by 3 h

Parameters		Inventory		Future changes			
		SQ	FS	PD1	PD2	PD1+CC	PD2+CC
Hydrological/Hydraulic	Inundation area	2721 ha	-	2445 ha	2365 ha	2748 ha	2713 ha
	Flood peak reduction	231 m^3s^{-1}	2 m^3s^{-1}	229 m^3s^{-1}	231 m^3s^{-1}	282 m^3s^{-1}	283 m^3s^{-1}
	Flood wave translation	0.75 h	3.75 h	0.50 h	0.75 h	1 h	1 h
	water level change	-	1.38 m	-	-	-	-

Table 2: Assessment of the hydrological (peak reduction, wave translation) and hydraulic (inundation area, water level change) FEM-parameters for a HQ100 – case study “Salzach”

Risk Assessment (WP4)

In WP4, a dynamic risk assessment approach was applied considering the land use development and the implementation of planned or intended flood defence and infrastructure measures. Accordingly, it includes the assessment of current and future risk (for the year 2030) with and without Climate Change.

Methodological framework

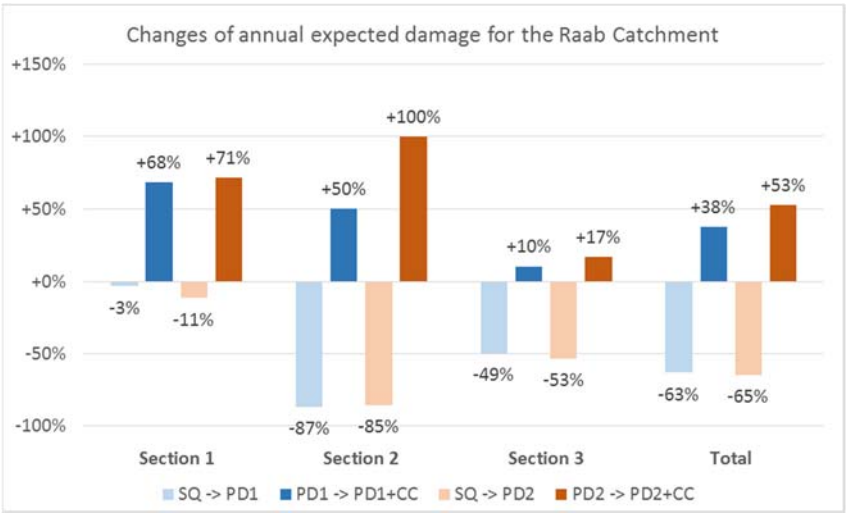
The basis for the risk assessment are the outcomes of WP2 and WP3. From WP2 the different land uses are used to determine the corresponding damage function and the inundation areas and water depths evolved in WP3 are defining the affected buildings and areas. After the Stakeholder Workshop, the damage functions have been adapted slightly so that higher water depth (>0.5m) is resulting in higher damage since it can be expected, that the effects of first defence measure is reduced then. The final damage functions can be found in the corresponding publication. As a result, the damage potential is calculated for each river section and each return period (HQ30, HQ100, HQ300) as an input for the RegioFEM evaluation matrix. Furthermore, the annual expected damage is also calculated to compare the different scenarios.

Work Package results

The damage potential for the Salzach and the Raab catchment show similar tendencies:

- Clear increase from HQ30 to HQ100 and HQ300 for each scenario
- projected engineering measure in PD1 lead to a significant improvement, but mainly in the corresponding river section
- The results on the residual risk in a HQ300 event is different for the case studies (almost no influence at the Salzach and an improvement in the Raab catchment without CC).
- The influence of increased runoff (10%) due to climate change has a noteworthy negative effect in both case studies partly even reversing the positive effects of the planned measures.
- The CC-induced changes are not always affecting the projected developments but do occur in other regions where no changes to land use and flood protection has occurred.

The annual expected damage can serve as a summary of the effects on the monetary evaluated flood risk since it includes the results from every return period. The following figure presents the changes for the Raab catchment with the scenarios PD1 and PD2 compared to the status quo (SQ) and the Climate Change scenarios compared to their corresponding scenario. The effectiveness of the planned measures can clearly be seen as well as the effect of the CC on each section. A detailed analysis, also presented in the publication, show that the increase due to CC is not resulting from the projected measures and the settlement development but from the increased runoff leading to an overtopping and bypassing of existing defence structures.



The results of WP4 and its integration into the RegioFEM framework for the Raab catchment are published in:

- Wesemann, J., Herrnegger, M., Löschner, L., Eder, M., Schober, B., Zahnt, N., Scherhaufer, P., Nordbeck, R., Seher, W., Habersack, H., Hogl, K. (forthcoming): Regionale Entwicklung des Hochwasserrisikos unter Berücksichtigung zukünftiger Entwicklungen (submitted, Hydrologie und Wasserbewirtschaftung)

Integrated floodplain evaluation - development of extended FEM (WP5)

The aim of this work package was to improve the existing FEM method which is already in use for floodplain evaluation in hydrological and hydraulic context for the current status of river floodplains. This existing FEM method was extended in consideration of findings from WP1 (risk transfer mechanisms), land use parameters (changes and trends in land use development and population growth from WP2), hydrological and hydraulic parameters (from WP3) and economic parameters (monetary risk assessment from WP4) in order to allow for the comparison of future changes in flood risk due to expected (technical, land use and/or morphological developments), and to develop compensation and risk transfer strategies between the riparians of river basins.

The **RegioFEM** - as the methodology was finally labelled to account for the regional dimension of the assessment - is a novel method to support future-oriented flood risk management at the scale of river stretches and (sub)catchments. It was developed in an interdisciplinary approach involving hydrologists, hydraulic engineers, spatial planners and political scientists, and their respective inventories of research methods (hydraulic modelling, GIS-based exposure assessment, analysis of policy instruments).
The RegioFEM is guided by four **overarching principles**:

i. Regional approach: Flood risk management is characterised by the reciprocal relations between upstream and downstream riparians. In pursuit of “better fit” between bio-physical system (i.e. the catchment of a river basin) and the administrative and judicial borders in flood risk management, the RegioFEM aims to support coordinated approaches in larger planning areas, such as river sections or, ideally, (sub)catchments.
ii. Intersectoral approach: As flood policies shift from flood defence to a more integrated management of flood risk there is a growing need to improve the sectoral coordination of policies at the nexus of water management and land management. The RegioFEM takes account of these interactions and provides a tool to promote cross-sectoral coordination, in

particular between the policy domains flood protection, spatial planning, infrastructure planning, and agriculture.

iii. Future-oriented approach: Flood risk is non-stationary and changes over time. To account for the long-term impacts of flood defences and modifications in river morphology, the possible consequences of climate change, as well as land development in riparian areas, the RegioFEM integrates expected developments in a scenario-based approach. It thus provides the basis for future-oriented flood management and anticipatory adaptation to future flood risk change.

iv. Replicable approach: Regional assessments of flood risk change and river basin approaches in flood risk management demand replicable methodologies. The RegioFEM method was developed in an iterative process using Austrian river stretches as case studies. To ensure its replicability, we used input data which is (as best as possible) widely available or at last easily accessible for both scientists and practitioners.

The generic **methodological approach** of the RegioFEM consists of **four consecutive steps**, with the option to involve different actors at different stages in the process (see Figure 1).

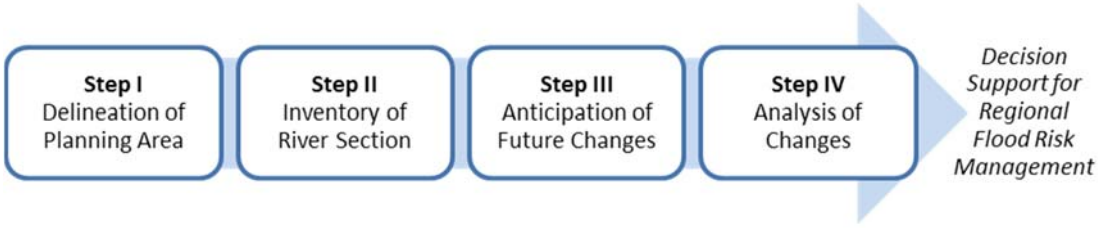


Figure 1: Sequence of the RegioFEM approach

We developed the RegioFEM in case study region I (Salzach) and applied it in its final form in the second case study region (Raab), as outlined in the following:

Step I: Delineation of the Planning Area

The first step of the RegioFEM is the selection and delineation of a planning area. Since the RegioFEM is a supportive tool for a regional/catchment-oriented flood risk management the defined study area can have different scales, e.g. a river reaches or entire river basins/catchment areas. In order to assess the changes in flood risk, the study area is divided into further river sections with the help of specific control points. Those control points can be placed at tributaries, municipalities (any administrative border), bottlenecks in the river morphology and/or settlements (land use criteria).

Our study site is located along the Raab River, a meandering lowland river in south-eastern Austria and western Hungary. We selected this river reach as a test site for the RegioFEM for three reasons. First, the original FEM had also been developed with the Raab as one of the case studies, which provides a good opportunity to compare the different methodological approaches. Second, the river reach is located in an Area of Potential Significant Flood Risk (APSFR) according to the Austrian implementation of the EU Floods Directive (2007/60/EC). In contrast to other regions of Austria, which were heavily affected by a series of major flood events (i.a. 2002, 2005, 2013), this region has not seen major flooding in recent times. However, specifically the areas surrounding the district capital Feldbach show a high risk of flooding and a number of flood protection measures have been and will be implemented to protect the area against a 100-year design flood. Moreover, in terms of land development, the region displays strong settlement dynamics and a large transport infrastructure project is currently being realised in the riparian areas to improve the accessibility of the region. Finally, we selected this case study because

we had support of regional and local authorities. They provided an existing hydrodynamic-numerical 2D-model of the Raab and supported the project team in organising and conducting a stakeholder workshop to reflect the feasibility of the RegioFEM (see section 2.5).The existing hydrodynamic-numerical 2D-model was generated with HYDRO_AS-2D, a standard modelling software in Austria, Germany and Switzerland. HYDRO_AS-2D uses SMS (Surface Water-Modelling-System) as a pre- and post-processing tool, which allows managing topographic data and visualizing modelling results.
Based on the existing model we divided the river reach into three river sections based on two cross-sections (CS1, CS2), which were primarily placed with regard to hydraulic aspects. Most of the discharge during a 100-year flood event remains in the main river channel due to natural or anthropogenic structures, e.g. dikes and weirs. In this case, we did not place a cross-section at the first bottleneck because the section would have been too short to detect significant changes.

Step II: Inventory of the river section (status quo)
Having defined and delineated the study area into different sections, we conducted an inventory of the current state (status quo) based on following eight parameters:

Flood Hazard	Hazard Exposure	Damage Potential
•Flood peak reduction [m^3s^{-1}] •Flood wave translation [h] •Inundation area [ha]	•Number of affected buildings [-] •Affected building land [ha] •Affected agricultural land [ha] •Number of affected plots [-]	•Potential damage to buildings and land [€]

The parameters are categorised into (i) flood hazard, (ii) hazard exposure and (iii) damage potential and determined for flood events with different return periods (e.g. HQ_{30}, HQ_{100}, HQ_{300}).
The main goals of the inventory are (i) the identification of significant sections of flood retention and runoff; and (ii) the identification of the spatial distribution of hazard exposed and vulnerable land uses.
For the evaluation of the inventory of the river reach, it was necessary to update the existing hydrodynamic-numerical model. We integrated existing linear flood protection measures as well as an already completed regional bypass for a state road (including two bridges over the Raab) into the hydraulic model. With these changes, the status quo model simulations were conducted to evaluate the current flooding situation in the river reach. The assessment (for a 100-year flood event) shows that the existing floodplains play an important role from a hydraulic/hydrological point of view. Totalling 1.950 ha, the floodplains reduce the peak discharge by approximately 10 % (28 m^3s^{-1}) and delay the flood wave by almost 13 hrs and 45 mins. These effects are rather evenly distributed across the three sections (flood peak reduction ranges from 7 and 11 m^3s^{-1}; flood wave translation rages from 4.0 to 5.5 h). In terms of flood risk, the inventory assessment indicates that about 960 buildings, 118 ha building land and about 1.600 ha agricultural land would be affected, with potential damage totalling about EUR 181 million. In total 7629 plots are affected in the case of 100-year flood event, most of them are in section A (2795).
The detailed assessment for the three sections (A-B-C) reflects the differences in land use: although the three sections are not of equal length, the assessment shows that section A predominately consists of agricultural land uses and has the largest flood retention effects (i.e. in terms of flood peak reduction and flood wave translation). Floodplains in section B, on the other hand, have a high concentration of

vulnerable flood hazard exposure and by far the highest damage potential, due to the location of the district capital Feldbach in this riparian area.

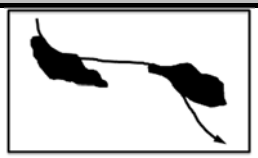
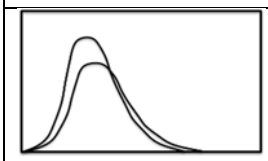
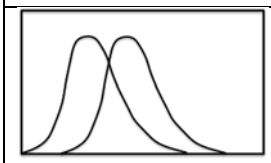
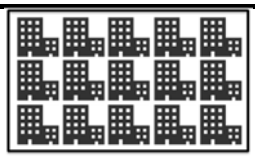
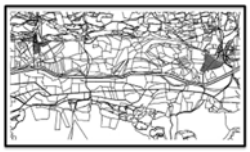
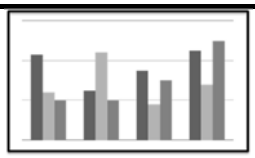
Parameter			Inventory (Status Quo)			
			A	B	C	Total
Flood hazard		Inundation area [ha]	727	598	625	**1.950**
		Flood peak reduction [m^3s^{-1}]	11	10	7	**28**
		Flood wave translation [h]	5.5	4.0	4.5	**13.75**
Hazard exposure		Number of affected buildings [-]	165	487	307	**959**
		Affected building land [ha]	16	67	35	**118**
		Affected agricultural land [ha]	616	450	513	**1.579**
		Number of affected plots [-]	2795	2269	2565	**7629**
Flood damage		Potential damage to buildings and land [Mio EUR]	17	118	46	**181**

Table 3: Evaluation matrix for the inventory of the Raab river reach and the respective sections (HQ_{100})

To further illustrate the relevance of the existing floodplains we also conducted “river channel” model runs, reflecting the hypothetical scenario that rivers are fully embanked and floodplains are completely disconnected from the main river channel. Modelling results show that in the absence of inundation areas, the peak reduction for the entire river reach would be negligent (1 m^3s^{-1}), the flood wave translation would be reduced to 5.5 hrs. These numbers clearly demonstrate the important role of floodplains as retention areas.

Step III: Projected developments and future changes

The third step of the RegioFEM aims to anticipate future developments in the study area and integrate these developments into the existing model. These developments (e.g. flood protection measures, settlement development, climate change impacts) can be derived from planned/projected flood protection measures and from zoning plans for settlement developments in the area of study until a

certain year (i.e. 2030). Additionally, a potential climate-induced increase in flood discharges can be integrated in order to assess the sensitivity and robustness of existing and planned flood protection systems. The future developments are integrated into the hydrodynamic-numerical model and the results are analysed and compared with the status quo and each other in the following step. For this study we considered the following set of future changes, which are likely to influence the flooding situation in the selected river reach in the next 10-15 years:

1. *Projected flood protection measures (2030)*
   In the next 10-15 years flood protection measures and infrastructure development is expected to change the river morphology in the study region. Plans show that linear flood defence structures totalling ~ 3.5 km will be constructed to reduce the flood risk in settlement areas of Feldbach and Fehring. In addition, the federal road (B68) will be completed, including another crossing of the Raab upstream of Feldbach.
2. *Projected settlement development (2030)*
   To account for changes in flood hazard exposure and damage potential we considered future land development as indicated in the municipal land use plans and the online GIS repository of the state of Styria[1]. We categorised potential development areas - most of which are located around the urban centres Feldbach and Fehring - according to the categories outlined above. Where necessary, we integrated complementary local flood defence measures (e.g. protective walls, earth deposits/dikes) into the hydrodynamic-numerical model.
3. *Climate change effects*
   To account for potential climate related impacts on flood runoff, we factored in a 10 % climate change allowance to the existing flood discharge levels entering the hydraulic model. This climate factor corresponds to the upper end of the possible range of changes in extreme flows and thus presents a worst-case assumption of possible climate change-induced impacts on future flood hazard in Austria. In the event that flood discharge exceeds the design flood of protective structures (which in Austria generally correspond to 100-year flood events plus safety margin), we assumed an overflow and not the failure (breach) of flood defences. It can be mentioned that a detailed assessment of possible changes in flood runoff was conducted for the study region, utilising climate projections from 11 different Regional Climate Models as an input into a calibrated hydrological model. The simulations showed a large spread of possible changes of extreme flood values towards an increase, but also towards a decrease. In light of these prevailing uncertainties, it was decided to use the above mentioned 10 % climate change allowance.

Step IV: Analysis and comparison of projected developments and future changes

The last step involves the assessment and comparison of the different future developments to demonstrate how future changes (in river morphology, floodplains, land use and flood discharge) would influence the flood hazard, hazard exposure and damage potential in the river reach. Calculated effects of the respective developments on future flood risk are investigated and compared with the status quo, which was derived in step II. For the assessment, the same parameters are used as for the inventory. The model runs indicate that future developments will have significant positive and negative effects on the flooding situation in the case study region, as illustrated in Table 4 for the entire river reach given a 100-year design flood.

[1] see www.gis.steiermark.at

Parameters		Inventory	Future Changes			
		SQ	PD1	PD2	PD1+CC	PD2+CC
Flood Hazard	Inundation area	1.950 ha	-7%	-9%	±0%	-2%
	Flood peak reduction	28 m^3s^{-1}	+11%	+7%	+25%	+25%
	Flood wave translation	13.75	±0%	-2%	-11%	-13%
Hazard Exposure	Number of affected buildings	959	-58%	-53%	-17%	+15%
	Affected building land [ha]	118 ha	-53%	-66%	-30%	-41%
	Affected agricultural land	1.579 ha	-4%	-5%	2%	-5%
	Number of affected plots	7629	-13%	-14%	±0%	-1%
Damage Potential	Potential damage to buildings and land	€ 181 Mio.	-72%	-69%	-52%	-43%

Table 4: Comparative evaluation matrix for the different future developments for the Raab river reach (HQ_{100}). The percentage of change are calculated in relation to the values of the Inventory SQ. Green colouring indicates positive effects, orange colouring negative effects; respective effects that are lower than 10% are coloured lighter.

1. Projected flood protection measures (PD1)
   Based on the modelling results, the projected flood protection measures will have a significantly positive effect on future flood risk. Although the linear defences will cut off parts of the floodplain and further reduce the existing inundation area (-7 %), the peak discharge reduction is expected to increase (+11 %). In terms of risk reduction, the flood defence measures are highly effective: they are in particular expected to more than halve both the number of currently affected buildings and the area of affected building land, and reduce the damage potential by about 72 %.
2. Projected settlement development (PD2)
   Land development, as projected in local land use plans, will have additional impacts on the flooding situation in the study region. Due to the development of riparian areas, the conversion of agricultural land into building land and complementary local flood defence measures (e.g. protective walls), the inundation area will further diminish compared to the status quo (-9%). The positive effects on flood discharge are expected to be a bit lower than in PD1 (+7%), while the flood wave will be (marginally) accelerated (2%). Consequently, also the expected effects on exposure reduction and damage mitigation are slightly lower compared to PD1.
3. Climate change effects (PD1/PD2 + CC)
   A +10% climate-related increase in flood discharge would have significant effects on future flood hazard and flood risk in the study region. Although the increase in flood discharge has no substantial effect on the inundation area, it would increase the flood peak reduction by +25% (compared to the status quo) and accelerates flood runoff by about 10%. The increase in flood

discharge would lead to overtopping of many existing protective structures, resulting in an increase in the affected housing and commercial areas and the activation of their corresponding damage potential. For instance, even without considering future land development the modelling of climate change effects (see PD1+CC) shows that the number of affected buildings would only be 17 % lower than in the status quo (as opposed to -58%) while the damage potential would be reduced by 52 % (as opposed to 72 %). For PD2+CC, some of the positive effects even turn negative (affected buildings), since the flood defence structures for the newly assigned settlement areas would be overtopped. This highlights the high sensitivity of linear structures against changes, indicating the need for further structural or organisational risk reduction measures.

Stakeholder Involvement

Since the RegioFEM is a supportive tool for stakeholder and decision makers in flood management and spatial planning, their involvement is possible and desirable at any steps of the RegioFEM. Due to their knowledge about the local/regional situations, their contribution can be relevant and an improvement of the results.

Based on our previous positive experiences in engaging with stakeholders in flood risk management, we organised a stakeholder workshop with local and regional representatives to jointly reflect the RegioFEM method and its application for the Raab river. To this end a four-hour workshop was held with 13 stakeholders at the district administration for Southeastern Styria in Feldbach. The participants were predominately representatives from the federal state of Styria, specifically the following administrative units: flood protection and water management, spatial planning and urban development, agriculture, and forestry. In addition, there was a representative from the district capital Feldbach and a representative of the inter-municipal water board which is in charge of river maintenance along this section of the Raab.

The workshop began with a presentation of the RegioFEM method and the results for the study region, and then proceeded with a moderated discussion (at two tables) of the options and limitations of implementing the RegioFEM in flood risk management practice.

The recordings show that the participants appreciated the RegioFEM as an innovative method to support catchment-oriented approaches in flood risk management. Regarding the data basis, participants highlighted that there are more accurate geo-referenced data sets available, such as the address and building registry (which however is not available to the public). Participants acknowledged the interdisciplinary approach of the method and the consideration of future land and infrastructure developments. In addition, participants appreciated the method's regional approach and the explicit consideration of upstream-downstream interactions. This was regarded as helpful to overcome barriers due to competing local interests in flood risk management and to establish a coordinated and integrated approach in floodplain management at regional level.

The climate change scenarios were generally considered useful to illustrate the sensitivity and robustness of the existing flood defences to additional increases in flood discharge. In light of the uncertainties of the underlying assumptions of the applied climate change factor, policy makers, however, are rather reluctant to use such an approach because it would indicate a strong need to adapt existing design values for flood protection - an issue which is highly debated in Austria, but currently not considered necessary.

Despite these concerns, in particular stakeholders in flood protection and water management regarded the RegioFEM as a useful basis for developing regional flood risk management programmes, which provide the possibility to e.g. legally secure areas for flood retention and thus prevent land and

infrastructure development in these areas. In addition, stakeholders considered the RegioFEM as a useful information basis for water boards and other inter-municipal cooperation in flood risk management. However, some participants, voiced concerns that the clear indication of beneficiaries of flood protection measures (e.g. flood retention measures) could rather result in growing competition rather and thus weaken existing cooperation efforts between municipalities or landowners.
The following publications present and discuss RegioFEM:

- Löschner et al. (under review): RegioFEM: a novel method for future-oriented flood risk management at the regional scale (Part I). Submitted for publication in: Journal of Flood Risk Management
- Eder et al. (under review): RegioFEM: supporting future-oriented flood risk management in an Austrian river reach (Part II). Submitted for publication in: Journal of Flood Risk Management
- Wesemann et al. (under review): Regionale Entwicklung des Hochwasserrisikos unter Berücksichtigung zukünftiger Entwicklungen / Regional development of flood risk under consideration of future development. Submitted for publication in: Hydrologie und Wasserbewirtschaftung (HyWa)

Stakeholder Involvement (WP6)

Since the RegioFEM is a supportive tool for stakeholder and decision makers in flood management and spatial planning, their involvement is possible and desirable at any steps of the RegioFEM. Due to their knowledge about the local/regional situations, their contribution can be relevant and an improvement of the results.
Based on our previous positive experiences in engaging with stakeholders in flood risk management, we organised a stakeholder workshop with local and regional representatives to jointly reflect the RegioFEM method and its application for the Raab river. To this end a three-hour workshop was held with 10 stakeholders at the district administration for Southeastern Styria in Feldbach. Eight researchers from the RegioFlood team completed the group of workshop participants. The stakeholders were predominately representatives from the federal state of Styria, specifically the following administrative units: flood protection and water management, spatial planning and urban development, agriculture, and forestry. In addition, there was a representative from the district capital Feldbach. It was perceived that the workshop should be manageable in terms of size, resources and duration and that – given the uncertainties related to future flood risk dynamics – non-specialists and laypersons might prevent an open debate of long-term flood management options.
The workshop was moderated, consisted of presentation, brainstorming, discussion and deliberation components. The basic communicative rule was that every stakeholder must have a say and that all opinions and perceptions must be tabled. The workshop began with a comprehensive presentation of the RegioFEM method and the results for the study region (see D10). The second half of the workshop was dedicated to a moderated discussion. At two tables the options and limitations of implementing the RegioFEM in flood risk management practice were discussed and recorded. One researcher from the RegioFlood team moderated each table and another one took notes. The moderator's task was to guide the discussion, stimulate debate and sum up all contributions. The idea behind the group discussions was that the participants have enough time to speak and listen in a non-hierarchical setting. Ideas and opinions should slowly develop so that at the end everyone has contributed to the topic. The participants were encouraged to establish their own views and visions on the issue of flood risk management and the RegioFEM.
The recordings show that the participants appreciated the RegioFEM as an innovative method to support catchment-oriented approaches in flood risk management. Regarding the data basis, participants

highlighted that there are more accurate geo-referenced data sets available, such as the address and building registry (which however is not available to the public). Participants acknowledged the interdisciplinary approach of the method and the consideration of future land and infrastructure developments. In addition, participants appreciated the method's regional approach and the explicit consideration of upstream-downstream interactions. This was regarded as helpful to overcome barriers due to competing local interests in flood risk management and to establish a coordinated and integrated approach in floodplain management at regional level.

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Despite these concerns, in particular stakeholders in flood protection and water management regarded the RegioFEM as a useful basis for developing regional flood risk management programmes, which provide the possibility to e.g. legally secure areas for flood retention and thus prevent land and infrastructure development in these areas. In addition, stakeholders considered the RegioFEM as a useful information basis for water boards and other inter-municipal cooperation in flood risk management. However, some participants, voiced concerns that the clear indication of beneficiaries of flood protection measures (e.g. flood retention measures) could rather result in growing competition rather and thus weaken existing cooperation efforts between municipalities or landowners.

Aside from substantive more policy-relevant results, the workshops also generated less tangible outcomes related to the workshops' procedural dimension and the applied method of linking knowledge domains. In the case study, the workshop assembled stakeholders from different policy fields and levels of government who do not usually exchange knowledge, share experiences or voice opinions in a comparable setting.

5 Schlussfolgerungen und Empfehlungen

The project RegioFlood generated novel insights into Austria's flood risk governance and, with the RegioFEM, developed an integrative methodology to support the implementation of future-oriented approaches in flood risk management at the regional level. The main conclusions from the project can be summarised as follows:

Flood protection associations facilitate inter-municipal cooperation in flood risk management

The nation-wide online survey among the chairmen of flood protection associations showed that these associations are established instruments of inter-municipal cooperation in water management. For one, they provide members a platform for the common representation of interests, and secondly they enable the joint realisation, financing and maintenance of flood protection infrastructure. At the same time, they are a sound proof of the "lived diversity" of flood protection associations in Austria.

The survey confirms that there is a considerable bandwidth, especially with regard to the structural characteristics of the associations. This refers both to the number and structure of the association members as well as to the total area of the association area and the population number of the municipalities organised in the associations. The association's members are predominantly rural municipalities with increasing populations, which look after larger river sections between 25-50 km in

length. The membership structure also shows strong horizontal but also vertical interdependence, i.e. different actors from different political and administrative levels as well as state and private actors cooperate with each other.
Intercommunal initiatives in flood prevention are "disaster driven", i.e. they require problem pressure due to flood damage and the resulting problem awareness of relevant municipal actors. On average, the flood protection associations have been affected by two flood events since 1980 according to the survey. Improving flood protection and flood retention are therefore priority objectives of the association's founding, alongside economic considerations and the development of building land. Cooperation in other thematic areas has a positive effect on inter-municipal cooperation in flood prevention, as does the promotion and support of flood protection measures by the Federal Government and the Länder.
The survey shows a wide range in the level of investments over the past ten years and a great diversity in the design of the contribution key for cost sharing between the members of the flood protection associations. The protection measures clearly focus on technical protection and maintenance, followed by retention measures, ecological measures and information and awareness raising. Preventive measures play a comparatively minor role in the field of spatial planning, which suggests a lack of link between the purpose of flood protection associations according to the WRG and spatial planning.
With regard to the success factors and obstacles, the survey provides different statements with regard to the results already discussed in the specialist literature. Most of the beneficial factors mentioned in the technical literature - such as leadership and strategies, regional integration, the use of synergy effects and economic advantages - were confirmed by the representatives. On the other hand, the picture is less clear with regard to the inhibiting factors. Some of the factors - such as the importance of transaction costs or power imbalances among the member municipalities - could clearly not be proven in the survey. Internal conflicts and unresolved compensation issues are the most obvious inhibiting factors.

Controlled flood storage leads to a “polycentrification” in Austria flood risk governance

Flood retention, in particular controlled flood storage, plays an increasingly prominent role in the portfolio of flood risk management strategies. Though a highly effective measure to reduce the risk of flooding for vulnerable areas, flood storage is land intensive and infringes on landowners’ property rights. Implementation efforts are thus often hampered by the lack of availability of land as well as by the growing demands of (agricultural) landowners for compensation of flood retention services. The proliferation of flood storage not only changes riparian land uses but also results in a shift of authority, power and agency to lower levels of government as well as to non-institutional actors, including the private landowners who provide the land for flooding but also those who benefit from flood retention.
Flood storage demands large areas of open land, mostly farmland. In the event of flooding, these areas are purposely flooded to alleviate downstream flood risk. By providing their land for flood retention, landowners, usually farmers, bear different types of costs e.g., reduced crop yields, damage to drainage systems as well as the depreciation in land value due to the foreclosure of development options. Downstream areas, on the other hand, benefit from the flood retention services provided upstream. Private homeowners, commercial businesses, public institutions or infrastructure operators benefit directly from reduced flood risk. Landowners of flood-protected land, both agricultural and (unbuilt) building land, benefit indirectly from flood storage because previously flood-prone areas are now located outside of flood hazard zones and may thus become legally suitable for development - usually implying in a significant appreciation in property value,

There are different options to realise flood storage on agricultural land. Public authorities may opt to make the land available for flood storage by means of legal expropriation, buyouts or land swaps. Or they may decide to not interfere in land ownership and instead compensate the flood-related infringements in land use and property rights. In the latter case two types of compensation approaches can be distinguished: (i) Public compensation: Compensation costs are allotted to the general public, i.e. those providing land for flood storage are compensated through tax money; (ii) Beneficiary compensation: Those benefiting from flood retention services cover (at least part of) the compensation costs to those providing land for flood storage.

While private actors emerge as important stakeholders in flood storage compensation schemes, public authorities play a pivotal role as intermediaries. Fundamentally, they represent the public interest by aiming to keep public expenditures low while providing the best flood protection possible. At the same time, they have the task to coordinate the respective stakeholder interests and to achieve a consensus for a compensation scheme.

Based on a case study of flood storage in an Alpine municipality in Salzburg we show that municipal and private actors at the local level can actively pursue flood storage measures on the complementary basis of the beneficiary-pays-principle. As there exist only few practical examples for innovative compensation schemes and flood protection policies are generally characterised by a persistence of hierarchical administrative settings, such bottom-up approaches in flood storage compensation require a strong willingness and capacity to experiment with new institutional and participatory designs. In this regard collaborating with and learning from the experiences of other local entities in implementing flood storage projects can help avoid or overcome typical stumbling blocks. As trust marks a precondition for the success of compensation schemes, participatory approaches can play an important role to build acceptance for the compensation payments and the beneficiary contributions. Finally, the case highlights that action at the local level requires a legal framework with a set of overarching rules as means to settle disputes and reduce the level of discord between the involved parties.

Whereas the case of flood storage in Altenmarkt indicates, at least in part, an evolving “polycentrification” of the Austrian flood risk governance system, the contribution of flood storage towards enhancing the resilience of riparian landscapes is more ambivalent. On the one hand, using agricultural land for controlled flood storage is an effective means to reduce the peak flow and the flood risk in vulnerable downstream areas. Against the likely climate-related increases in flood discharge, flood storage areas may also serve as buffer and contribute toward enhancing the climate robustness of flood protection schemes. Flood storage on open land thus assumes an increasingly prominent role in the portfolio of flood risk reduction strategies.

Catchment-oriented flood risk management: aligning policy aims with policy instruments

The coordination of upstream-downstream relations calls for regional approaches, ideally at the level of river basins or (sub)catchments, as advocated by the EU Floods Directive (EFD). Despite policy advances and the implementation of flood risk management plans for defined river sections (i.e. Areas of Potential Significant Flood Risk, as defined by the EFD), regional floodplain management that accounts for the reciprocal interrelations between upstream and downstream riparians are so far only partially reflected in the Member States’ legal and institutional frameworks.

While policy frameworks are slow to adapt to the changing demands of a nascent “spatial water governance”, in recent years innovative policy instruments have emerged to address the challenges of regional floodplain management. In the aftermath of a succession of extensive flooding in Europe, in particular following the seminal floods of 2002 that affected large parts of the Danube and Elbe River Basins, flood policies have pursued a fundamental shift from technical flood defense to a more

integrated approach of flood risk management. In the process, policy approaches outside the traditional, rather technical engineering emerging, giving way to policy instruments that span sectoral boundaries and incorporate regulatory or financial means to achieve a better coordination of interests between upstream and downstream riparians.

In the project RegioFlood we explored the issue of regional floodplain management from an instrumental perspective, which we differentiate according to (i) regulative instruments in regional floodplain management; (ii) cooperations between upstream and downstream riparians; and (iii) mechanisms of financial compensation and burden-sharing. Depending on the overarching policy aims and objectives in a given river catchment, each of these instruments may - by itself or in combination with other instruments - provide an effective and legitimate approach to enhance regional flood risk management. Our case study show that (i) regulatory instruments in regional floodplain management are effective ways to prevent the encroachment of settlements into hazard areas and to secure large areas for flood protection, specifically measures aiming to provide more room for the rivers, including flood retention and flood runoff; (ii) upstream-downstream cooperations in the form of flood protection associations are well-established instruments of inter-municipal cooperation in water management, that provide members a platform for the common representation of interests, and enable the joint realization, financing and maintenance of flood protection infrastructure; (iii) compensation and burden-mechanisms are decisive economic framework conditions for the realization of regional flood protection measures, with a fair distribution of burdens according to the beneficiary-pays or solidarity principle is the prerequisite for successful implementation.

Importantly, these instruments often have complementary characteristics. The strengths of inter-municipal cooperation lie on the one hand in the balancing of costs and benefits between upper and lower riparians, and on the other hand in the adaptable planning area. This instrument shows weaknesses in land use planning. Regional planning is regulative, but is oriented towards administratively defined regions, especially with regard to regional spatial planning programmes. In addition, the institutional asymmetries and externalities typical of upstream-downstream relations cannot be recorded and balanced out.

These complementarities raise the question of the interfaces between these regional instruments. One possible interface is to secure agreements made in intermunicipal cooperation by means of the regulatory instruments of land provision. In order to map the areas of action, i.e. (partial) catchment areas or river sections, accordingly, regional sectoral programmes can be considered in spatial planning and regional water management programmes in protective water management. Sovereign planning at the regional level often reaches acceptance limits, especially if the initiative for this is based on an overarching planning level. Thus, regional planning in Austria is in a weak position by international standards, especially with regard to the implementation of its contents. The comparatively far-reaching autonomy of the municipalities and their ability to influence higher political levels (policy integration) limit the scope for action of regional planning in practice. One solution to this problem of acceptance may be to integrate (protective) water management planning (but also other planning bodies in river basins) into cooperative processes at regional level and thus to initiate or support sovereign approaches to land use planning, such as regional planning or regional water management programmes. Regional planning associations or cooperations within the framework of (small) regional development concepts can serve as a platform for the necessary intersectoral coordination and regional burden-sharing.

RegioFEM: a novel methodological framework for future-oriented, regional flood risk management

With the RegioFEM (Regional Floodplain Evaluation Matrix), we developed a novel approach to support future-oriented flood risk management at the scale of river sections and (sub)catchments. The RegioFEM integrates the quantitative and qualitative research methods from the fields of hydrology, hydraulic engineering, spatial planning and political science to assess the dynamic changes in flood risk in consideration of projected flood protection measures, expected settlement and infrastructure development and the likely climate-induced changes in flood runoff.

A particular strength of the RegioFEM concerns its explicitly future-oriented approach. By integrating projected flood protection measures and expected land and infrastructure development into the hydrodynamic-numerical modelling, the RegioFEM allows decision makers to account for the fact that investments in (flood defence) infrastructure but also planning decisions (e.g. to zone building land in flood-prone areas) have profound and long-term consequences for future changes in flood hazard and flood risk at regional and local level. The RegioFEM considers the different drivers of flood risk change (including climate change) to provide an information basis for developing anticipatory adaptation measures.

Second, the RegioFEM's catchment-oriented approach supports regional flood management decisions which take into account the upstream-downstream interrelations of river riparians. By delineating planning areas on the basis of hydrologic/hydraulic or land use parameters, the RegioFEM applies a bio-physical rather than an administrative-judicial perspective as a starting point for the assessment. It thus provides a basis for improving the "spatial fit" for the political sphere of action in regional flood risk management. Moreover, by placing control points to divide the planning areas into sections, the RegioFEM enables a nuanced assessment of flood risk, which dissects the different effects to locate sections or areas, where the expected changes in flood hazard, exposure or damage are particularly strong. On this basis, the RegioFEM can support the spatial identification of power asymmetries, by showing i) which areas/riparians benefit from flood alleviation measures (such as a retention basins), ii) which areas/riparians bear the burden and costs of flood alleviation measures (such as linear defences which may increase flood discharge in downstream areas) and iii) which areas/riparians provide the necessary land resources, such as agricultural land, for realising a retention service for the downstream benefit. If considered useful, this information on the spatial distribution of risks and benefits may then be used for developing burden-sharing mechanisms including compensation schemes e.g. for agricultural land owners, or for assessing the financial contribution of beneficiaries for the construction and/or the maintenance of flood protection schemes.

Third, as the RegioFEM was developed in an interdisciplinary effort combining the research methodologies of natural and social sciences, it also considers the increasing sectoral interrelations that come with the policy shift from flood defence to a more integrated approach in managing flood risks. As flood protection is no longer the sole responsibility of hydraulic engineers, there is a growing need to improve cross-sectoral policy coordination at the land-water nexus, especially with spatial and infrastructure planning, but also with agriculture. The RegioFEM makes these sectoral interdependencies evident by showing the unintended side-effects of flood defences on land development ("levee effect") or by demonstrating that flood retention measures are often land-intensive and infringe on existing property and land use rights of (agricultural) land owners. The RegioFEM thus also provides a policy support for adjusting] sectoral policies in order to make them mutually enforcing and consistent. This inter-sectoral policy orientation of the RegioFEM moreover points to the importance of involving different stakeholders and groups of actors. Engineers, hydrologist, planners, agronomists, as well as local/regional administrative officials and land and property owners, can play a pivotal role in co-developing and supporting the implementation of the RegioFEM in practice across traditionally separated policy domains.

Lastly, a considerable strength of the RegioFEM lies in its replicable and adaptable methodology. In its present form, the RegioFEM uses input data sets that are easily accessible and available. Apart from an existing hydrodynamic-numerical model, it uses land-related data sets which are usually provided for free or at low cost from the responsible administrations. As the method is designed to support decision makers and practitioners in flood risk management, it is assumed that those applying the RegioFEM would have access to the necessary data sets. If more accurate or detailed data are available, the proposed data sets may however be substituted to generate a more refined assessment. In this vein, the methodology of the RegioFEM is principally adaptable, in the sense that specific parameters may be reduced or new ones added, if users decide to focus on particular parts of the assessment, e.g. the hazard or the exposure assessment. Concerning the latter, e.g. population based parameters or geo-referenced census may in particular be considered useful to assess how many and/or which types of residents (e.g. elderly) are affected by flooding, both currently and in the future.

Concerning the weaknesses of the RegioFEM, critics could point out that the methodology is generally too elaborate for an uptake in practice. If fully implemented, the RegioFEM is admittedly rather lengthy process, which may exceed the operational and financial capacities of other research consortia, let alone engineering/planning offices or flood management authorities. In particular the anticipation of future developments, i.e. the integration of projected flood protection measures and land development decisions into the hydrodynamic-numerical model, requires a lot of effort.

C) Projektdetails

6 Methodik

The integrated approach of floodplain management of RegioFlood combined the following analytical perspectives of floodplain development.

1) **Floodplains as biophysical systems:** As an integral part of the fluvial system floodplains have the capacity to store and hence to contribute significantly to the reduction of peak flows and to the prolongation of wavelengths. This biophysical approach generally assumes a catchment or river basin-wide perspective of flood dynamics.
2) **Floodplains as planning systems:** Floodplains are potential hazard areas. Land development decisions are based on the spatial extension of flood events with a legally defined level of occurrence (e.g. hundred years flood). However, land development is to a large extent determined by administrative borders. The dependency of downstream riparians on risk-aggravating as well as risk-mitigating measures taken upstream is, therefore, not fully accounted for in prevailing planning practices (Frerichs et al., 2003).
3) **Floodplains as institutional systems:** Obviously there is a "problem of fit" between the biophysical and the administrative planning system (Moss, 2002). Establishing an effective management of floodplains calls for catchment- or river basin-oriented approaches. These can be met by institutional arrangements comprising formal as well as informal mechanisms of coordination and compensation between upstream and downstream riparians.
4) **Integrated floodplain management:** Overcoming the problems of downstream-upstream dependencies and developing effective forms of regional floodplain management hence necessitates the integration of the above analytical perspectives on floodplain development. This integrated framework assumes that modelling the hydrologic/hydraulic effects of floodplains is essential for evidence-based decision-making. The modelling can indicate which floodplains in a river basin have the greatest alleviating effects on downstream flooding and thus should be prioritized for securing flooding areas. Secondly, the framework places a strong emphasis on spatial planning and its role in (i) assessing potential land use conflicts, (ii) allocating land uses for the restoration of river floodplains and (iii) enhancing river basin-wide cooperation (Seher and Löschner, 2014). Finally, the conceptual framework acknowledges that overcoming the "persistent policy delivery gap" (Moss and Monstadt, 2008) calls for context-specific solutions to negotiate upstream-downstream relations. Implementing schemes to restore/secure floodplains involves a number of different risk transfer mechanisms that may be based on voluntary cooperation, regulation, regional planning instruments, and financial compensation schemes.

Since the EU Floods Directive demands the preservation and/or restoration of floodplains, the assessment of floodplain effectiveness has become a central element of flood risk research in recent years. To determine most effective floodplains the EU funded ERA-Net CRUE project "PRO_Floodplain" (Habersack et al. 2008) developed the FEM-method (Floodplain Evaluation Matrix) as a tool for decision-makers and stakeholders for an integrated evaluation and ranking of river floodplains. This FEM focused on hydrological and hydraulic parameters, but also allowed for the consideration of additional parameters describing ecology and sociology. The project also highlighted future research demand in terms of extending this method for evaluating compensation strategies. The complex relationships and interactions between downstream and upstream municipalities call for the integration of risk transfer

mechanisms, land use developments and population dynamics as well as risk assessments in order to strengthen the integrative approach. Accordingly, the overall aim of the RegioFlood project was to develop an "extended FEM-method" (RegioFEM) which could serve as a comprehensive and effective supportive tool for decision makers and stakeholders. Figure 1 outlines the integrative implementation of our conceptual framework in six work packages.

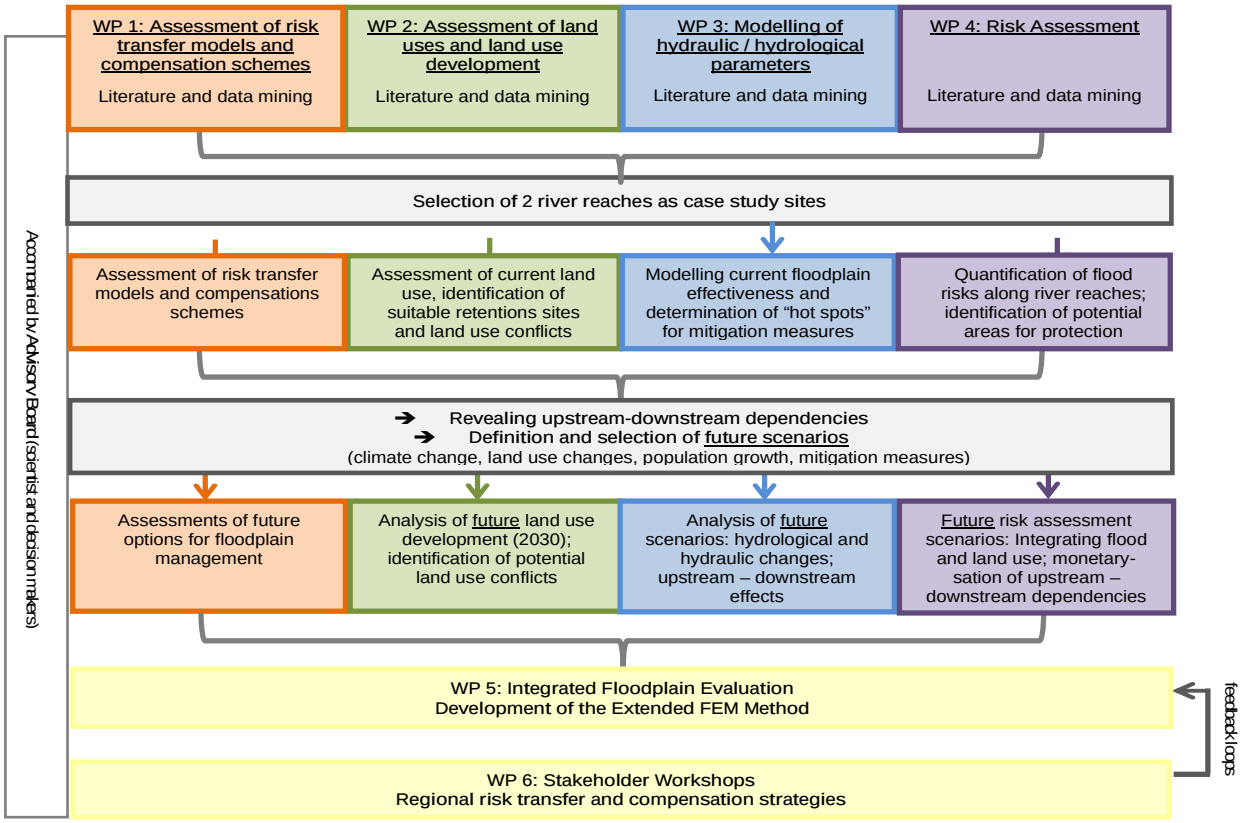


Figure 1: The interdisciplinary and integrative research design of RegioFlood

The research activities and methodological approaches in the six WPs can be summarized as follows:

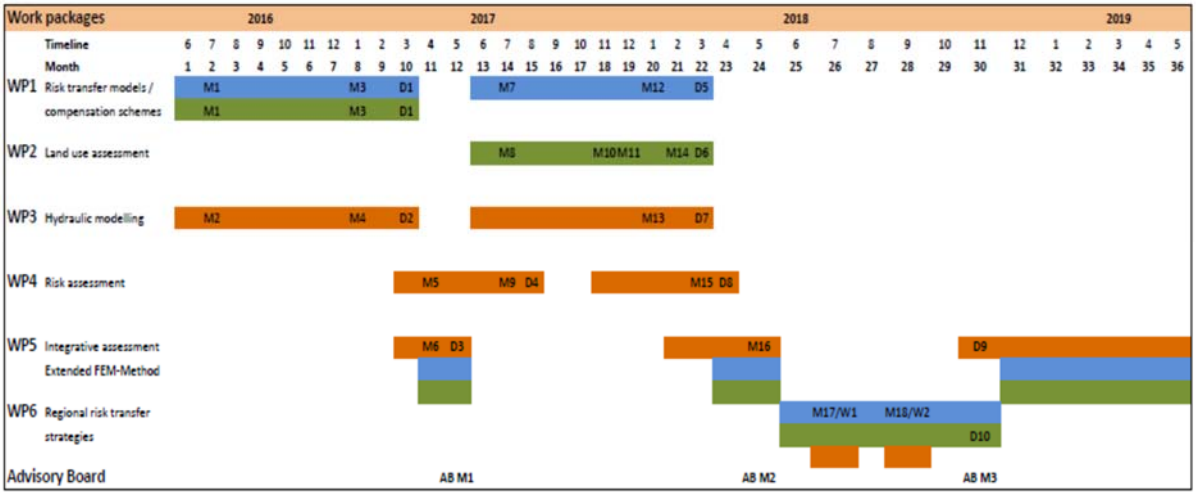
- In **WP1** we analyzed three different governance arrangements (regulatory instruments, cooperative instruments and financial compensation schemes) towards regional floodplain management. Based on document analysis, expert interviews and an online survey among water management boards we conducted several local and regional case studies (Altenmarkt, Mittersill, Unteres Unterinntal, Lower Austria, and Vorarlberg) to deepen our understanding of the challenges and benefits of the respective governance arrangements.
- **WP2** analyzed the prevailing land uses and assessed potential future land use developments (until the year 2030) in flooding areas with 30-, 100- and 300 years recurrence intervals. In coordination with WP4 (risk assessment) and WP5 (RegioFEM) we conducted a GIS-based assessments of flood hazard exposure and checked the availability of land for flood storage with likely future land developments in the Salzach and Raab study sites.
- Within **WP3**, the status quo and future scenarios of the case study sites were simulated with a hydrodynamic-numerical 2D-model (Hydro_AS-2D) for different flood events (HQ30, HQ100, HQ300). The modelling results were used in WP4 and WP5 to analyse and to compare the status quo and the effects of the future developments in the study area. The selected future

scenarios were based on the findings of WP1, WP2, and WP4. The hydrological and hydraulic results of these assessments form the basis for WP4 (risk assessment) and WP5 (development of extended FEM method - RegioFEM), in order to display the complexity of upstream-downstream relations in regard to flood water storage and runoff as well as its compensation.

- The main objective of **WP4** was to derive an objective evaluation criteria, which reflects the monetary effects of different flood protection measures and land use development. The flood risk and the effects of the different scenarios, including the Status Quo, derived in WP2 and WP3 was monetized based on the damage potentials derived for the return periods HQ30, HQ100 and HQ300. The development of the risk assessment scheme and the choice of damage functions is based on a literature review (M5) and was tested in the Salzach case study. There, especially the scenario V1, with the retention basin already under construction, was used to evaluate the project results with the official numbers for the planned flood defence measure. After the Stakeholder Workshop, the methodology was slightly adapted and confirmed by the experts and applied in the Raab catchment study area. The final results is the damage potential for the current state and each scenario, including the climate change, for the whole planning area and the different sections which is included in the RegioFEM evaluation matrix of WP5.
- In **WP5** the further development of the FEM (Floodplain Evaluation Matrix) was conducted. The developed RegioFEM expands the original FEM, spatially, temporally and thematically. It (i) focuses on flood-related planning at the scale of river stretches and (sub)catchments, (ii) integrates expected future changes in flood risk by considering the consequences of human interventions in the river morphology, land development and the potential climate-related change on flooding, and (iii) accounts for the sectoral interrelations between different policy domains, notably flood protection, spatial planning and agriculture.
- In **WP 6** a stakeholder workshop was conducted for the Raab case study region. The task of the workshop was to jointly reflect the RegioFEM method with relevant stakeholders and to discuss the results of its application in the case study region of the Raab river.

7 Arbeits- und Zeitplan

The work and time schedule of the RegioFlood project is characterised by a cost-neutral extension of the project duration to 36 months. This extension enabled us to cope with the complexities of the RegioFEM method, the various regional and local case studies, the stakeholder workshop, and to produce more publications than initially planned. All milestones and deliverables of WP1-WP6 described in the project proposal were successfully completed. The sequence of activities in RegioFlood followed the work and time schedule outlined in the project proposal.



8 Publikationen und Disseminierungsaktivitäten

The main purpose of the RegioFlood project was to deliver high-quality journal manuscripts, to be presented at international conferences and published in internationally recognized journals. As indicated here, more publications and presentations have been delivered than envisioned in the project proposal:

Journal papers and book chapters: 6 planned, 8 delivered

(1) Löschner L, Eder M, Wesemann J et al. (2019): RegioFEM: a novel method for future-oriented flood risk management at the regional scale (Part I) (submitted to Journal of Flood Risk Management)
(2) Eder M, Löschner L, Wesemann J et al. (2019): RegioFEM: supporting future-oriented flood risk management in an Austrian river reach (Part II) (submitted to Journal of Flood Risk Management)
(3) Wesemann J, Eder M, Löschner L et al. (2019): Regionale Entwicklung des Hochwasserrisikos unter Berücksichtigung zukünftiger Entwicklungen (submitted to Hydrologie & Wasserwirtschaft)
(4) Löschner L, Nordbeck R, Schindelegger A, Seher W. (2019). Compensating Flood Retention on Private Land in Austria: Towards Polycentric Governance in Flood Risk Management? Landscape Architecture Frontiers, 7(3), 32-45. https://doi.org/10.15302/ J-LAF-1-020004
(5) Löschner L, Seher W, Nordbeck R, Kopf M (2019): Blauzone Rheintal: a regional planning instrument for future-oriented flood management in a dynamic risk environment. In: Hartmann T, Slavíková L, McCarthy S (Eds.): Nature-Based Flood Risk Management on Private Land. Springer, pp. 141-154.
(6) Nordbeck R, Löschner L, Scherhaufer P, et al (2018): Hochwasserschutzverbände als Instrument der interkommunalen Kooperation im Hochwasserrisikomanagement. Österreichische Wasser- und Abfallwirtschaft, 70: 316–327.
(7) Seher W, Löschner L (2018): Balancing upstream-downstream interests in flood risk management: experiences from a catchment-based approach in Austria. In: Journal of Flood Risk Management 11, pp. 56-65.
(8) Seher W, Löschner L (2018): Instrumente der Raumplanung für die Flächenvorsorge gegen Hochwassergefahren. In: Rudolf-Miklau F, Kanonier A (Eds.): Regionale Risiko Governance: Recht, Politik und Praxis. Verlag Österreich, pp. 445-459.

Conference presentations: 3 planned, 6 delivered

(1) Löschner, L., Seher, W., Schinkinger, K. (2018): Catchment-oriented flood risk management: possibilities and limitations of spatial planning, June 2018, Ljubljana, Slovenia.
(2) Löschner, L., Nordbeck, R., Seher, W. (2018) Compensating Flood Storage – a Thin Line between solidarity and envy? The case of Mittersill. LAND4FLOOD Workshop, 19-21 June 2018, Riga/Latvia.
(3) Nordbeck. R., Eder M., Habersack H. et al (2018): Regioflood – Regionales Überflutungsflächenmanagement als Instrument der Flächensicherung und Klimawandelanpassung. 19. Österreichischer Klimatag, 23.-25. April 2018, Salzburg.
(4) Seher, W. (2018): Governance in Flussgebieten – Steuerungsmöglichkeiten und Instrumente. PlanerInnenTag 2018, 18. – 19. Juni 2018, Waidhofen/Ybbs.
(5) Löschner L (2018): Policies and Instruments: Mobilising Private Land for Flood Risk Management. IWRA Webinar - N°15. How Private Land Matters in Flood Risk Management. International Water Resources Association, June 20, 2018, Riga, LATVIA
(6) Löschner L, Nordbeck R, Zahnt N, Scherhaufer P, Hogl K, Seher W (2017): Gemeindeübergreifende Zusammenarbeit im Hochwasserschutz: Ergebnisse aus einer österreichweiten Online-Umfrage. ÖWAV-Jahrestagung Hochwasserschutzverbände, 27. April 2017, Zell am See.

Linkage to the COST Action Land4Flood (CA16209)

Members of the RegioFlood consortium are involved in the EU COST Action Land4Flood “Natural Flood Retention on Private Land” (CA16209), a network encompassing over 100 researchers, practitioners, governmental and policy actors with multiple disciplinary backgrounds from across the EU and beyond. We used the COST Action as a platform to disseminate thematically relevant findings from RegioFlood to a wider, international audience. Inter alia, we presented our work in joint publications, including a book project and a special issue (see publication n°5 and n°7, respectively). We also conducted a two-day international workshop in Salzburg, where we engaged with local actors (including landowners) and visited flood storage sites to learn more about the implementation of flood compensation mechanisms. Finally, findings from RegioFlood were incorporated into the following Policy Brief on “Compensation for Flood Storage”:

- Löschner L and Schindelegger A (2019: Compensation for Flood Storage. Policy Brief N° 3. International Water Resources Association. (The policy brief is available in English, French, Spanish, Portuguese and Czech: http://www.land4flood.eu/iwra-policy-brief-3-2018/)

Diese Projektbeschreibung wurde von der Fördernehmerin/dem Fördernehmer erstellt. Für die Richtigkeit, Vollständigkeit und Aktualität der Inhalte sowie die barrierefreie Gestaltung der Projektbeschreibung, übernimmt der Klima- und Energiefonds keine Haftung.

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