WP4

Deliverable D 4.4.2

General evaluation tool based on table calculation or GIS software for possible later assessment of other restoration projects ensuring a simplified and standardized assessment of such projects, which is described in the manual (output 5.1).

Work Package (WP)	WP4: Flood prevention pilots
Activity	Activity 4.4
Deliverable	D 4.4.2 General evaluation tool based on table calculation or GIS software for possible later assessment of other restoration projects ensuring a simplified and standardized assessment of such projects, which is described in the manual (output 5.1).
Activity-leader	TUM
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1. Summary

In the scope of Workpackage (WP) 4, the Floodplain Evaluation Matrix (FEM) – Tool was developed, a general evaluation tool for assessing floodplain restoration projects. The FEM-Tool (D4.4.2) uses input data from hydraulic modelling, ecosystem services (ESS) analysis, ecological assessments, habitat modelling, stakeholder and extended cost-benefit analysis to determine if a restoration project is recommended or not. The first step of the assessment with the FEM-Tool is evaluating the current state (status quo) of an active floodplain with the Floodplain Evaluation Matrix (FEM) method. The FEM method is evaluating hydrological, hydraulic, ecological and socio-economics parameters to assess the effects of the floodplain on flood risk reduction, ecology and socio-economics. A minimum set of parameters, including at least one parameter of each category (hydrology, hydraulics, ecology, socio-Economics), must be assessed for the FEM method. After evaluating the current state, the planned restoration projects can be assessed, starting with a stakeholder analysis followed by assessing the restoration project and its effects. Therefore, the FEM method is applied again, but a more detailed analysis is conducted, including three additional parameters. During this more in-depth analysis, it is assumed that the restoration project is implemented and the FEM parameters are recalculated. The results are compared with the FEM results of the current state. If the FEM evaluation is improving after the restoration project and the additional analysis (stakeholder analysis, additional parameters, ecosystem services, habitat modelling) favors the project, it is recommended to implement it. This report gives an overview about the FEM-Tool in its basic form as a Microsoft Excel Tool working with Macros. The FEM-Tool will be further developed in the additional Workpackage 6 of the Danube Floodplain project and integrated a GIS software as an add-on. It is recommended to use the upgraded FEM-Tool, which is described in D6.1.1 (Danube Floodplain, in prep.).

2. Introduction

The goal of D4.4.2 was to create a tool that assembles all relevant data from hydraulic modelling, ecosystem services, ecological assessments, habitat modelling, stakeholder and extended cost-benefit analysis to assess restoration projects. Figure 1 shows an overview about all possible input data that can be included in the FEM-Tool.

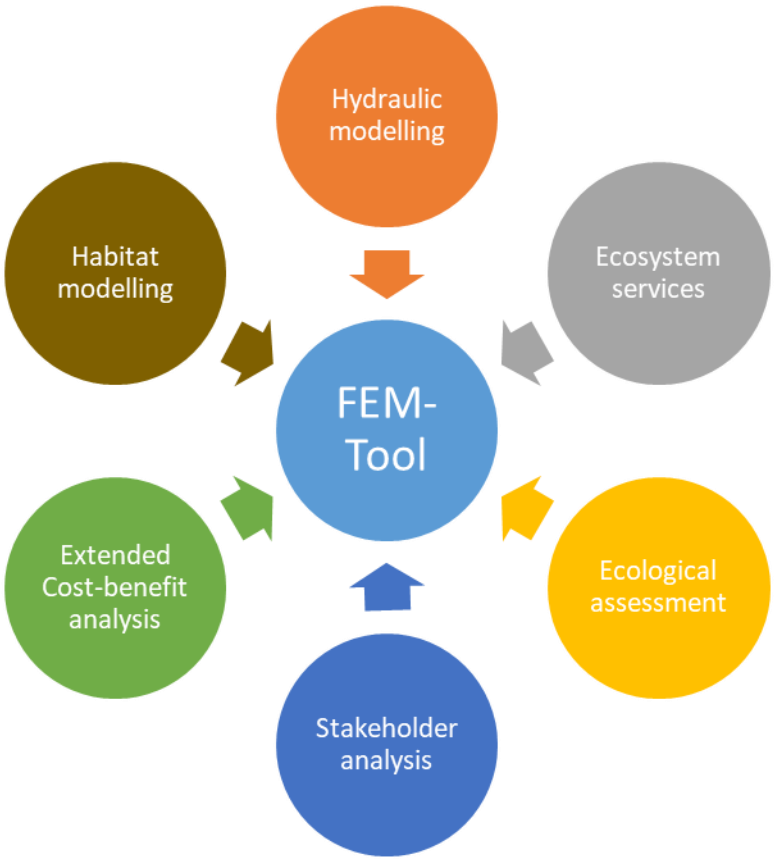

Figure 1: Overview about all possible input data that can be included in the FEM-Tool

The FEM-Tool offers the possibility to enter all relevant input data and proceed the FEM results leading to a recommendation if a restoration project should implemented or not. The basic form of the FEM-Tool was created in Microsoft Excel. Macros are used to proceed the entered input data automatically. The FEM-Tool will be further developed in the additional Workpackage 6 of the Danube Floodplain project and integrated a GIS software as an add-on. This will improve the usability and the speed of the analysis. The upgraded tool will be tested in pilot sites (Bistret and Suhaia-Zimnicea – RO, Middle Tisza – HU) to assure that the tool's data processing is working without bugs, the handling and concept are understood by the end-users and that the tool fulfills the functional requirements.

It is recommended to use the upgraded FEM-Tool, which is described in D6.1.1 (Danube Floodplain, in prep.). Nevertheless, the overarching principles of the tool are the same in the basic as well in the upgraded version and described in this deliverable.

3. FEM-Tool

The evaluation of a restoration project with the FEM-Tool is based on two main steps. First, the evaluation of the current state of an active floodplain with the FEM method followed by an assessment of the restoration state, including stakeholder analysis, FEM analysis, ecosystem services, habitat modelling etc. In Figure 2, a schematic overview including the workflow of the FEM-Tool is shown.

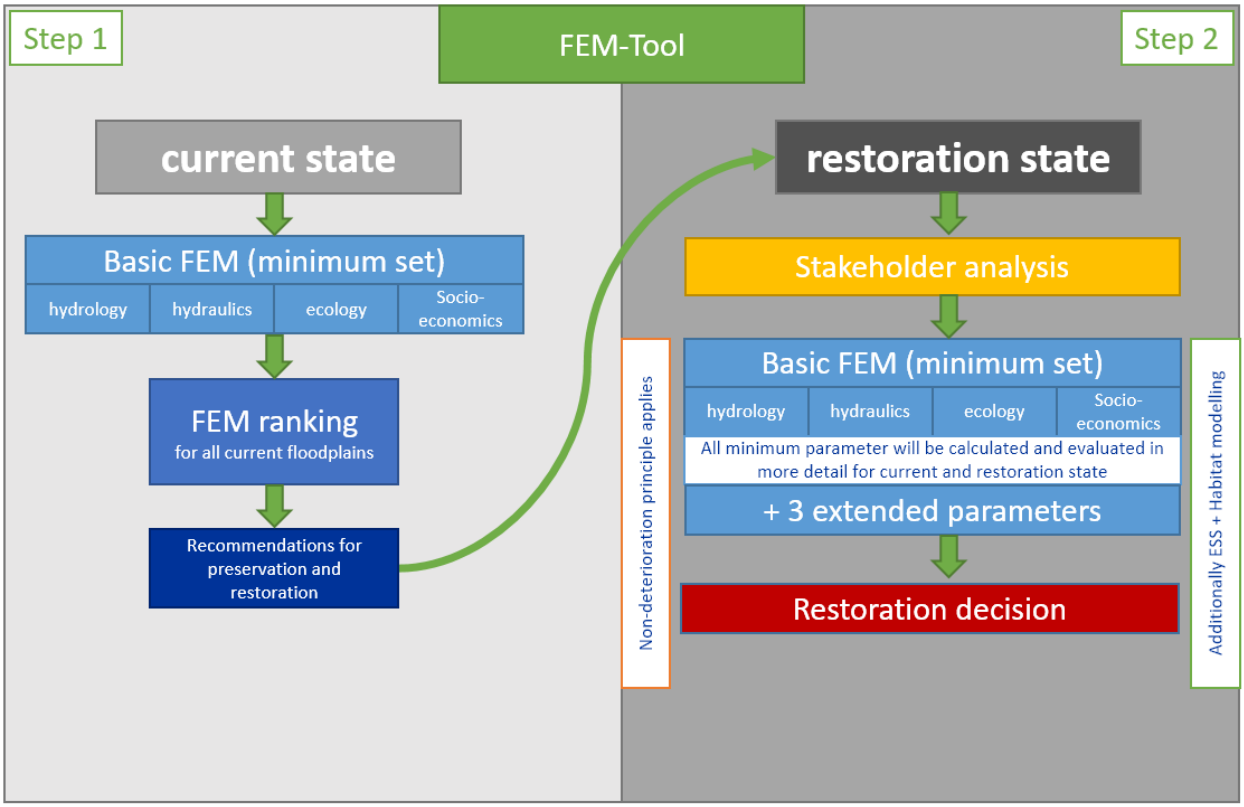

Figure 2: Schematic overview including the workflow of the FEM-Tool

The first step of the FEM-Tool is assessing the current state of an active floodplain with the FEM method. In D3.2.1 (Danube Floodplain, 2021a), the FEM method and the methodology for the identification of active floodplains are described in detail. Here, we give only a short overview about concept of the FEM method. For further information about the calculation of the parameters etc. please have a look at D3.2.1 (Danube Floodplain, 2021a).

The current FEM-Tool is based on Microsoft Excel and works with Macros proceeding the entered input data automatically. In the general settings, the river name, country, editor and date of the analysis can be entered. Next, it is noted that all active floodplains along the river should be identified using the method described in D3.2.1 (Danube Floodplain, 2021a) (Table 2). The number of identified floodplains has to be entered and then additional floodplain sheets are created automatically according to the number of floodplains. In the created floodplain sheets, the floodplain code, name and results for the FEM analysis of the current state can be entered (Table 1).

Table 1: Input mask of the floodplain sheets for the FEM results of the current state (the FEM results are only exemplary)

FEM TOOL			
Floodplain Evaluation Matrix Tool			
Floodplain 1			
Code: DU_AFP_01		Name:	
Minimum Parameters			
Parameter	*Value*	*Unit*	*FEM-Evaluation*
Hydrology			
relative peak reduction ΔQrel:	3.00	%	5
flood wave translation Δt:	250	min	3
Hydraulics			
water level change Δh:	64	cm	5
Ecology			
connectivity of floodplain water bodies:	3	-	3
Existence of protected species:	36	Nr	3
Socio-economics			
Potentially affected buildings:	2	Nr/km²	3
Land use:	4.1	-	5
Restoration project	No		

It is possible to choose a floodplain ranking and restoration project in two drop-down lists (Table 2). If a floodplain ranking (Table 6) is desired, an additional sheet called “Ranking” will automatically be created. If a restoration project is evaluated, the additional input masks for a description of the restoration project (Table 7), stakeholder analysis (Table 8), restoration project evaluation (Table 9), ecosystem services (Table 10), and habitat modelling (Table 11) are displayed in each floodplain sheet. The different input masks will be explained in detail in this chapter.

Table 2: Input mask for the general and specific settings of the FEM-Tool

FEM TOOL		
Floodplain Evaluation Matrix Tool		
Settings		
General		
River:		
Countries:		
Editor:		
Date of Analysis:		
Please identify all active floodplains at the river by using GIS software or maps. Decide wether you want to do a ranking and/or restoration projects at the floodplains. Please change the FEM parameter thresholds if necessary. For a detailed FEM parameter description please have a look at the FEM Handbook.		
Specific		
Number of identified floodplains:	10	
Floodplain ranking:	Yes	
Restoration projects:	Yes	

For assessing the current state of an active floodplain with the FEM method, a minimum set of parameters must be used. The minimum parameters chosen for Danube Floodplain project are shown in blue in Table 3. The additional parameters are optional and provide additional information.

Table 3: Overview of FEM-parameters for the Danube Floodplain project (in blue minimum set, in green additional parameters)

Hydrology	Hydraulics	Ecology	Socio-Economics
peak reduction ΔQ	water level Δh	connectivity of floodplain water bodies	Potentially affected buildings
flood wave translation Δt		Existence of protected species	Land use
Additional parameters:			
effects (pos./neg.) in case of extreme discharges	flow velocity Δv	Existence of protected habitats	Precence of documented planning interests
	bottom shear stress	Vegetation naturalness	
		water level dynamics	
		Potential for typical habitats	
		ecological water body status	

After the calculation of the minimum parameters for the active floodplain, the performance of each parameter is determined with the minimum parameters. Three levels of performance are possible for each parameter:

- High performance (5 points, colour code: blue)
- Medium performance (3 points, colour code: green)
- Low performance (1 point, colour code: yellow)

The thresholds can be selected for each river individually under consideration of specific characteristics of the river and its floodplains. In Table 4, the selected thresholds for the Danube River and the input mask in the FEM-Tool are shown as an example. It is recommended to start with the thresholds used at the Danube River and if necessary, adaptation can be made. At the selected tributaries in the Danube Floodplain project, the same thresholds were used. Based on the selected thresholds, the performance of the floodplain for each parameter can be determined. The FEM-Tool allows the user to set these thresholds on its own (Table 4).

Table 4: Input mask in the FEM-Tool and the used thresholds in Danube Floodplain for the Danube River to determine the performance (low, medium, high) of the minimum FEM-parameters

Thresholds			
FEM Parameter	***Low (1)***	***Medium (3)***	***High (5)***
peak reduction ΔQrel:	< 1.00 %	1% - 2%	> 2.00 %
flood wave translation Δt:	< 1 h	1 - 5 h	> 5 h
water level change Δh:	< 10 cm	10 cm - 50 cm	> 50 cm
connectivity of floodplain water bodies:	1	3	5
Existence of protected species:	< 1	20	> 40
Potentially affected buildings:	> 5.0 n/km²	5 - 1 n/km²	< 1.0 n/km²
Land use:	< 2	2 - 4	> 4

After determining the performance, the need for preservation and the demand for floodplain restoration can be evaluated. First, the need for preservation is determined. A floodplain has to be preserved if at least one parameter of the minimum set is evaluated with a 5 (high performance). After that, the restoration demand is defined. Based on the minimum parameter evaluation, each floodplain is assigned to one of three groups (low, medium, high demand for restoration). The thresholds can be selected for each river individually. In Table 5, the selected thresholds for the Danube River and the input mask in the FEM-Tool are shown as an example. In the Danube Floodplain project, the following thresholds were used: If a maximum of one parameter is evaluated with 1 (low performance) and two other parameters received a 3 (medium performance), the floodplain shows a low demand for restoration. The sum of the points received has to be ≥ 27, for getting a low demand for restoration. Floodplains with total points between 26 and 23 have medium restoration demand (Table 5). All floodplains with <23 points show a high demand for restoration. Based on the total number of points, a ranking of the floodplains is possible. It is recommended to start with the thresholds used at the Danube River and if necessary, adaptation can be made.

Table 5: Input mask in the FEM-Tool and the used thresholds in Danube Floodplain for the Danube River to determine the restoration demand (low, medium, high)

Ranking		
Demand Class	***Rule***	***Min Sum Points***
High Demand	All below Medium Demand	below 23
Medium Demand	max 2x Medium(3) and 2x Low(1) or 3x Low(1)	23 - 26
Low Demand	max 2x Medium(3) and 1x Low(1)	27

The FEM-Tool allows to rank the active floodplains based on their current FEM results and determine the need for preservation as well as the restoration demand automatically in the Ranking sheet (Table 6), which is created if a ranking is desired and chosen in the general settings (Table 2).

Table 6: FEM ranking including need for preservation and restoration demand

FEM TOOL Floodplain Evaluation Matrix Tool										
	Floodplain	Hydrology		Hydraulics	Ecology		Socio-Economics		Need for Preservation	Restoration Demand
		peak reduction ΔQrel	flood wave translation Δt	water level change Δh	connectivity of floodplain water bodies	Existence of protected species	Potentially affected buildings	land use		
1	DU_AFP_01	5	3	5	3	3	3	5	Yes	Medium
2	DU_AFP_02	1	1	1	3	5	5	5	Yes	high
3	DU_AFP_03	3	5	5	1	3	3	5	Yes	Medium
4	DU_AFP_04	5	5	5	5	5	3	3	Yes	low
5	DU_AFP_05	1	1	1	3	5	5	5	Yes	high

Followed by the evaluation of the current state of the floodplain and the ranking with the FEM method, the restoration project and its effects are assessed. First, the restoration project and the selected measure can be described (Table 7).

Table 7: Input mask for the description of the restoration project including the selected measure

Restoration project	
Description of restoration project:	
Selected measures:	

After the description, the stakeholder analysis starts, where all the affected stakeholders should be listed and their interest and power (high, medium, low) determined. Planned measures for the stakeholder involvement should be described as well.

Table 8: Input mask for the stakeholder analysis in the FEM-Tool

Stakeholder analysis			
Name of organisation	**(General) Type of stakeholder**	**Interest**	**Power**
Measures planned for the Stakeholders			
Name of organisation	**Measure description**		

National public authorities
Regional public authority
Local public authority
Sectoral agency
Interest groups including NGOs
Higher education and research
International organisation
General public

A more in-depth FEM evaluation follows the stakeholder analysis to determine the effects of the restoration project. During this more in-depth analysis, it is assumed that the restoration project is implemented and the FEM parameters are recalculated. For the recalculation of the minimum FEM parameters, more detailed data sets are used than it is necessary for the assessment of the current state of the floodplain with the FEM method. For example, to calculate the hydrological and hydraulic parameters 2D models must be used. For the 1st step (assessment of the current state), it is recommended to use 2D models as well, but there is the exception that 1D models can be used for this step if no 2D models are available. This exception is for the 2nd step not given. For the ecological parameters (connectivity of floodplain water bodies, protected species), more detailed data sets should be used e.g. on-site analysis with experts to determine the protected species living on the floodplain. To evaluate the land use vulnerability, more detailed maps than the CORINE land cover data set should be used. Besides, the usage of more detailed data sets for the evaluation, at least three additional parameters are recommended. The user can select these additional parameters. One

parameter that is highly recommended to include in the assessment is the extended cost-benefit analysis parameter. In D4.3.1 (Danube Floodplain, 2021b), it is described how to apply the extended CBA. Besides the cost-benefit parameter, in this example, the bottom shear stress change as a hydraulic parameter and the water level dynamics as an ecological parameter were chosen as additional parameters. The FEM results, assessed with the more detailed data sets after the restoration, are compared with the FEM results of the current state (Table 9). If one FEM parameter is improving and the additional analysis (stakeholder analysis, additional parameters, ecosystem services, habitat modelling) favors the project, it is recommended to implement it.

Table 9: Input mask for comparing the current FEM results with the results after the implementation of the restoration project (the FEM results are only exemplary)

Restoration Project evaluation					
Parameter	***Value Current State***	***Value Restoration State***	***Unit***	***FEM Current State***	***FEM Restoration State***
Hydrology					
peak reduction ΔQrel:	3	4	%	5	5
flood wave translation Δt:	250	330	min	3	5
Hydraulics					
water level change Δh:	64	54	cm	5	5
Sediment balance:	0.4	0.5	-	3	3
Ecology					
connectivity of	40	42	%	3	3
floodplain water bodies:	6	8	days		
Existence of protected species:	36	47	Nr	3	5
Water level dynamics:	3	3	-	3	3
Socio-economics					
Potentially affected buildings:	2	3	Nr/km²	3	3
Land use:	4.1	4.2	-	5	5
Cost-Benefit-Ratio:		0.6	-		3
List of non-monetarised benefits:					
Restoration recommendation:			**Yes**		

The floodplain's ecosystem services can also be assessed and entered into the FEM-Tool (Table 10). It should be assumed for this analysis that the restoration project is implemented. In D4.2.2 (Danube Floodplain, 2020a), the results of the ecosystem services assessment in the Danube Floodplain project are presented and the methodology is described.

Table 10: Input mask for the ecosystem services in the FEM-Tool

Ecosystemservices					
Category	ESS	Intensity	Percentage of total Area	Intensity (Restoration)	% of area (Restoration)
Provisioning ESS	agricultural product				
	wood				
	animal product				
	game meat				
	honey; beehive products				
	fish or fish products				
	water (drinking, irrigation)				
Regulating ESS	local climate regulation				
	air purification				
	low water regulation				
	flood retention				
	nutrient retention				
	noise regulation				
	provision of habitats				
Cultural ESS	recreational activity				
	water related activity				
	tourism				
	education				

The results of a habitat modelling can also be summarized in the FEM-Tool, as shown in Table 11. In D4.2.3 (Danube Floodplain, 2020b), the habitat modelling at pilot sites along in the Danube region is summarized and described.

Table 11: Input mask in the FEM-Tool for results from a habitat model

Habitat Modelling					
Percentage of lateral connection during an HQ2-5:			**Curent State**	**Restoration**	
					%
Habitat type	**Area [ha]**	**Flow velocities**		**Area [ha] (Restoration)**	**Flow velocities (Restoration)**
Floodplain					
Backwater					
Channel					

Based on the assembled data in the FEM-Tool from hydraulic modelling, ecosystem services, ecological assessments, habitat modelling, stakeholder and cost-benefit analysis, a decision should be made if a restoration project should be implemented.

4. Concluding remarks

With the FEM-Tool, a general evaluation tool for floodplain restoration projects was developed. The tool gives the opportunity to assemble all relevant data from hydraulic modelling, ecosystem services, ecological assessments, habitat modelling, stakeholder and extended cost-benefit analysis to assess restoration projects. The basic form of the FEM-Tool was created in Microsoft Excel. Macros are used to proceed the entered input data automatically. In the Danube Floodplain project's extension (WP6), the FEM-Tool will be further developed by the implementation in a GIS software and tested in pilot sites (Bistret and Suhaia-Zimnicea – RO, Middle Tisza – HU). The integration of the FEM-Tool into a GIS software will improve the usability and the speed of the analysis. The tests with pilot site data will assure that the tool's data processing is working without bugs, the handling and concept are understood by the end-users and that the tool fulfills the functional requirements. The upgraded FEM-Tool will be described in D6.1.1 (Danube Floodplain, in prep.) and it is recommended to use the upgraded version since the usability and the speed of the analysis are better.

References

Danube Floodplain. D 3.2.1. Report on the evaluation of floodplains along the Danube River. Deliverable title: Priority list with potential preservation and restoration areas (based on FEM-tool); 2021a.

Danube Floodplain. D 4.3.1. Report on assessment results of the CBA applied to the pre-selected pilot areas including ESS, stakeholders and biodiversity as input for D 4.4.1 and therefore part of the feasibility studies in output 4.1; 2021b.

Danube Floodplain. D 4.2.2. Report, database and maps of ESS analysis of the pilot areas including a list, description, assessment, and ranking concerning the demands and supplies; 2020a.

Danube Floodplain. D 4.2.3. Report on the assessment of biodiversity in the pilot areas including a database and maps of pilot areas' biodiversity and habitat modeling as input for 4.4.1 and part of output 4.1; 2020b.

Danube Floodplain. D 6.1.1. Upgraded Floodplain Evaluation Matrix Tool as GIS add-on or as standalone tool; in preparation.