KLEE – Adaption to climate change in the Este catchment

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ABSTRACT

Climate change will have far-reaching effects on the discharge and the morphology of the entire hydrological system of the Lower Elbe and its tributaries such as e.g. the Este River (Nehlsen et al., 2012). The essential goal of the research project KLEE is to develop a detailed integrated approach for the Este River which covers the complete catchment and aims to mitigate the negative effects resulting from climate change. The concept takes into account the different interests (water management, environment, agriculture, climate protection, …) of the planning authorities concerned as well as of the local stakeholders in the two districts of Stade and Harburg and in the city of Buxtehude.

The project partners are the i) administrative districts Harburg and Stade, ii) public services of the city of Buxtehude, iii) Hamburg University of Technology and iv) TuTech Innovation GmbH. KLEE is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. In this article an overview on the project and the first working phase will be given.

1 PROJECT AIMS AND OVERVIEW

The essential aim of KLEE is to develop a detailed integrated concept for the mitigation of the negative effects resulting from climate change for the Este River. The entire catchment area will be considered in the context of a large-scale approach. Potential adaption measures will be analyzed and assessed in detail and will then be summarized in a compendium. In addition, a permanent network of all stakeholders will be established in order to reach an early involvement of the stakeholders into the planning process and to achieve wide acceptance of the planned measures. The main steps of the KLEE project are summarized as follows:

1) Measurement and monitoring of the hydrological and sedimentological system of the Este River and its catchment
2) Recalibration and extension of existing numerical models (Nehlsen et al., 2012)
3) Analyses of the effects of climate change on the hydrological and sedimentological system using numerical models (2)
4) Analyses of local adaption measures and assessment of the effects on the complete system
5) Development of a catalogue of adaption measures including positive and negative effects as well as an economic, legal and social assessment of feasible and accepted solutions
6) Implementation of pilot projects

Parallel to these work packages, a permanent project board is installed and learning and action alliances will be performed in order to ensure stakeholder participation at an early stage for the optimisation of adaption measures.

2 PROJECT AREA

The project area of KLEE covers the complete catchment of the Este River (fig. 1). The river is divided into two main parts: The upper Este in the district of Harburg is a typical moraine river. The catchment area is dominated by agricultural use. The lower Este in the district of Stade is a marsh river, which is dominated by the tidal influence of the Elbe. From these different conditions, different interests for sediment management and for flood protection are arising. While the Este River originally was a narrow, strongly meandering river, it is now heavily influenced by human interventions (fig. 2). For example, in the area of Moisburg the bed slope has increased by about 70 % since 1922. During the same period the bottom widths have increased by about a third, while the maximum water depths have more than doubled (Heins, 2011).

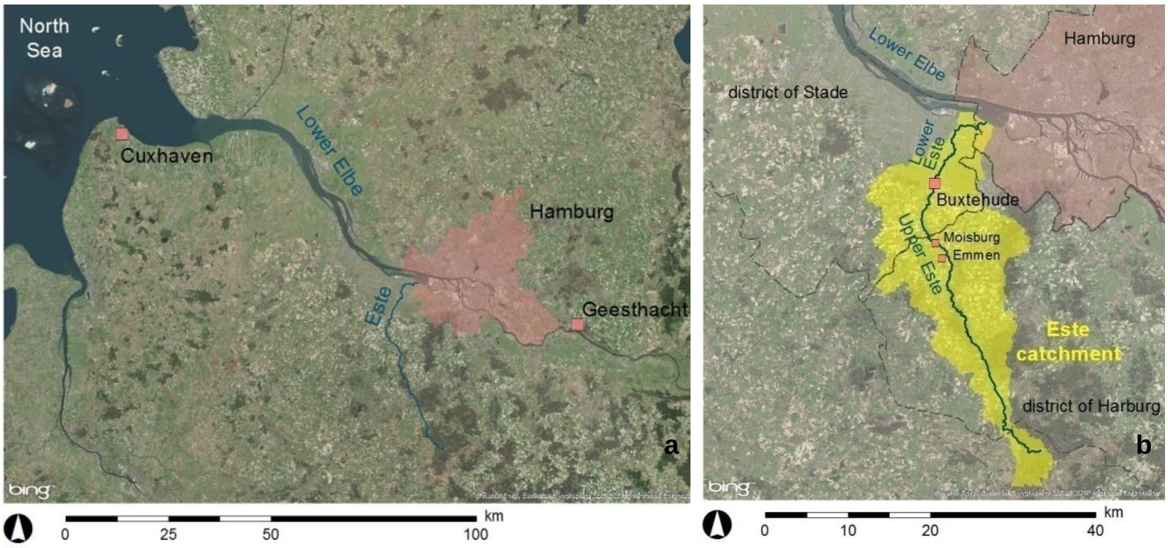

Figure 1 Project area. (a) Overview map. (b) Este catchment

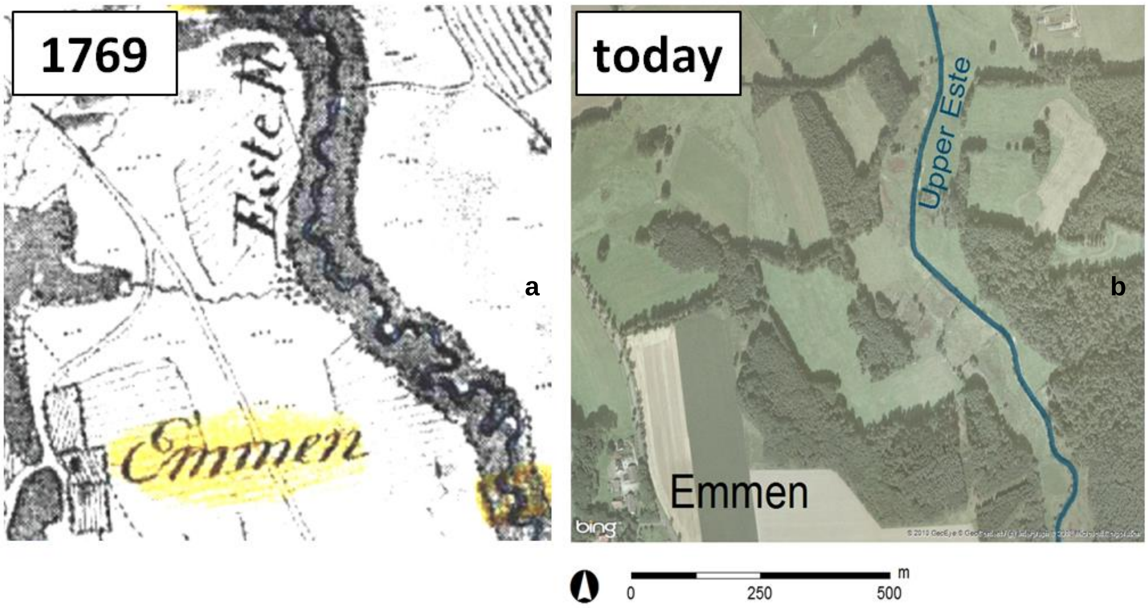

Figure 2 Straightening of the Este River. (a) Strongly meandering river (about 1769) (Heins 2011). (b) Straightened river (today)

3 MAIN CHALLENGES

First investigations on potential impacts of climate change on the hydrological and sedimentological system of the Este River and its catchment have been carried out within the research project KLIMZUG-NORD (Nehlsen, 2011). Besides flood protection, particularly sediment management has been identified as a major challenge for the future throughout the whole catchment area.

Due to the straightening, at many points of the river the critical flow velocities are exceeded even for low discharges (table 1). This leads to bank erosion and consequently to deposition in areas with lower flow velocities (fig. 3). Figure 4 shows, that for wide areas of the catchment a significant, climate change-induced increase of soil erosion must be expected.

Annuality (approx)	Discharge Emmen [m³/s]	Flow velocity (Actual state) [m/s]		Flow velocity (Restoration) [m/s]	
NQ	1,0	0,46		0,17	
MQ	1,7	0,56		0,18	
HQ 5	10,0	0,97		0,41	
HQ 10	15,0	1,08	permanent exceeding of v_{cr}	0,46	exceeding of v_{cr} during flood
HQ 50	23,0	1,23		0,49	
HQ 100	36,5	1,29		0,51	

Start of motion according to ZANKE: v_{cr}= 0,24 m/s
Start of motion according to HJULSTRÖM: $0{,}16 < v_{cr} < 0{,}28$ m/s
characteristic grain diameter: 0,25 mm

Table 1 Critical flow velocity vs start of sediment motion (example: Este km 7,55) (Nehlsen, 2011)

Figure 3 (a) Bank erosion (photo: Deckwerth, ULV Este). (b) Sedimentation (photo: Gumz, Landkreis Harburg). (c) Resulting maintenance measures at the Este River (photo: Deckwerth, ULV Este)

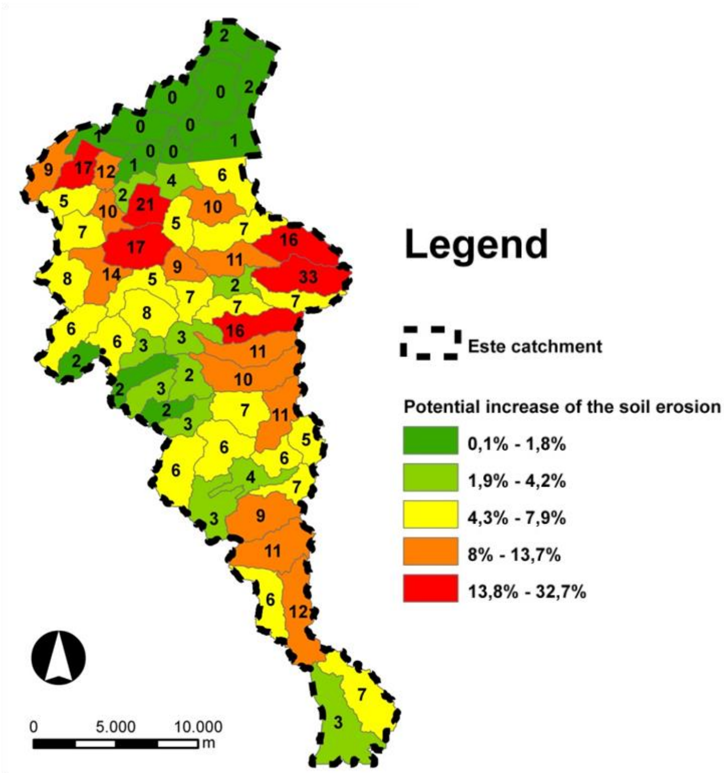

Figure 4 Potential increase of soil erosion in the Este catchment caused by climate change (difference between climate change scenario A1B and the actual climate status (C20) (Nehlsen, 2012)

4 FIELD MEASUREMENTS

For more detailed analyses of the system behavior and to improve and extend existing numerical models it is necessary to describe hydrological and morphological processes quantitatively. Within an extensive measurement program (table 2 and fig. 5), relevant parameters are observed and a long-term component will be developed which is used to monitor the effectiveness of the adaption measures.

Parameters	Device / method	Explanation / aim
Discharge	Flow measurement system	• Recalibration of the rainfall-runoff-model • Correlation between discharge and suspended sediment concentration • Monitoring
Precipitation	Precipitation measuring station	• Determination of the erosivity of individual events • Event-driven calibration of the rainfall-runoff-model • Monitoring
Bathymetry	Single-beam echolot/ GPS rover	• Quantification of the material transport for sediment balance (long-term and event-related) • Monitoring
Sediment concentration	Turbidity probe	• Localization of the main sources within the river system • Correlation between discharge and suspended sediment concentration • Monitoring

Table 2 KLEE measurement program

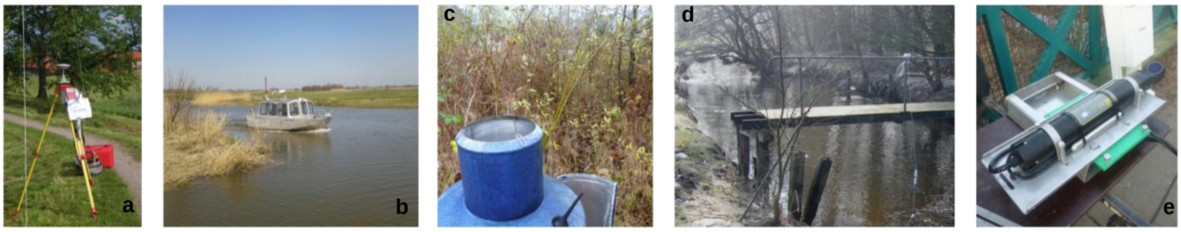

Figure 5 KLEE measurement program. (a) GPS rover. (b) Boat NEKTON with single-beam echolot. (c) Precipitation measuring station. (d) Turbidity probe. (e) Flow measurement system

5 MEASURES

The general effectiveness and the general potential of different adaption measures have been analyzed within the KLIMZUG-NORD project. As a result, some measures (e.g. reactivation of the natural potential for water and sediment retention) have been identified as positive where further analyses and development of the solutions are making sense in order to develop a reasonable adaption to climate change. These solutions will be developed and analyzed in terms of feasibility and effectiveness on the local scale as well as under economic, legal and social aspects. In detail the following measures will be considered:

- Creation of additional retaining capacity for flood retention
- Measures for the retention of water on the surface
- Restoration of the natural morphodynamic conditions
- Measures for the retention of sediment on the surface

Specifically for the sediment management, this means: an adapted land cultivation, prevention of erosion, restoration measures (fig. 6) as well as the creation of riparian zones at Este tributaries. For example, the widespread use of mulch seeding would lead to a significant reduction of potential soil erosion within the entire catchment even if the effects of climate change are taken into consideration (fig. 7).

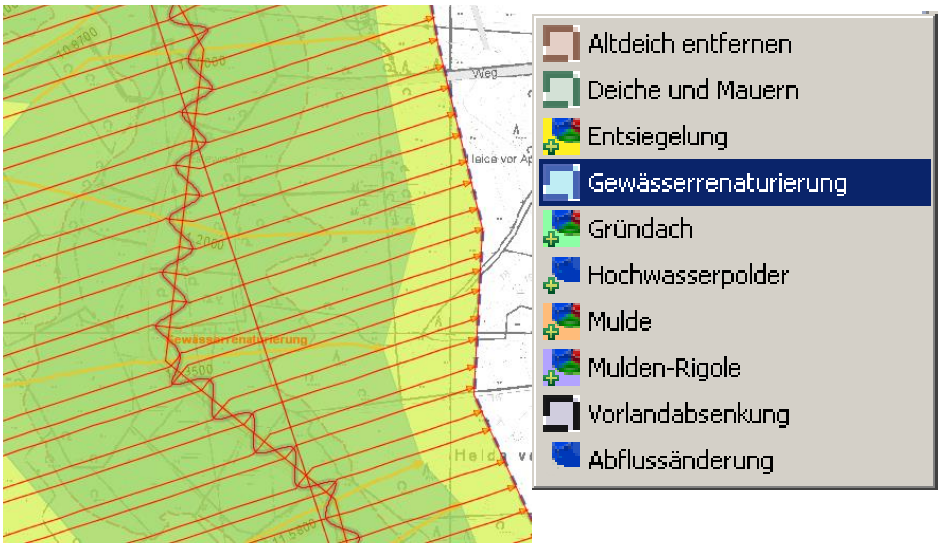

Figure 6 Planning of a river restoration with Kalypso Planner Client (Nehlsen, 2011) (www.tuhh.de/wb/forschung/software-entwicklung/kalypso.html)

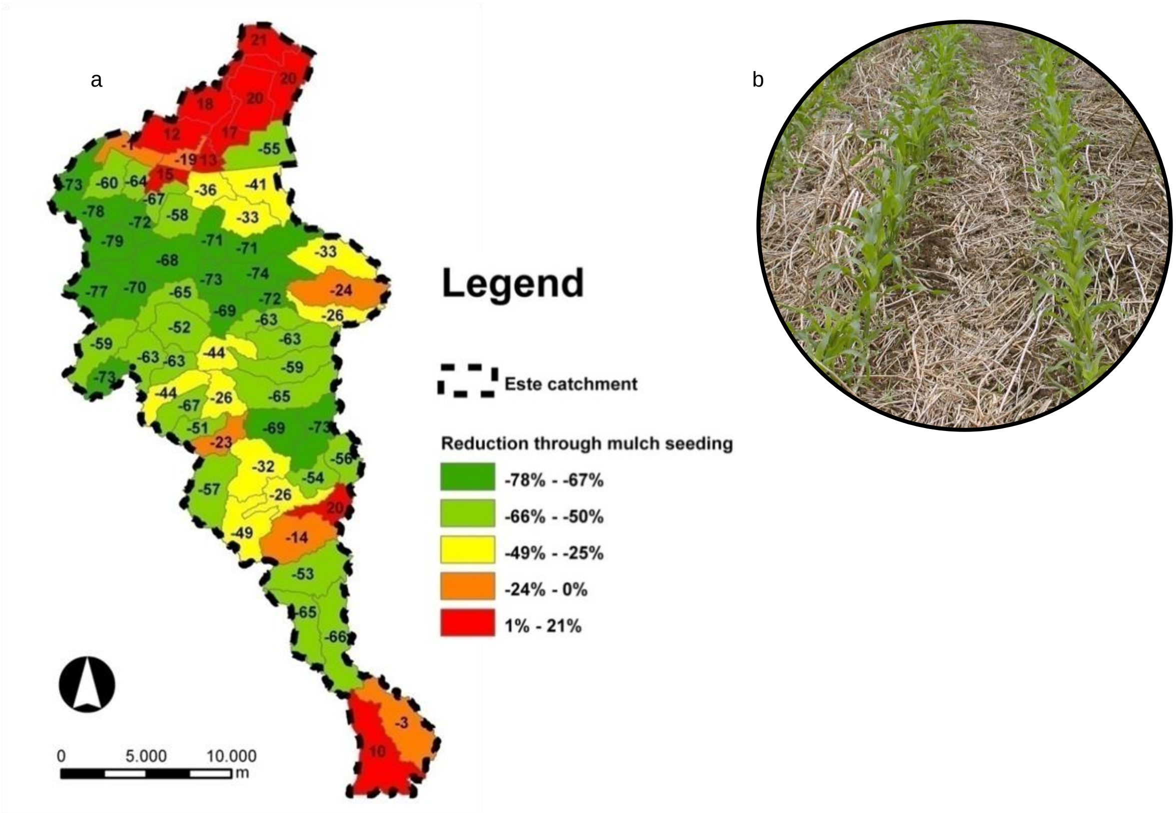

Figure 7 (a) Potential reduction of soil erosion through mulch seeding (difference between climate change scenario A1B in combination with mulch seeding and the actual climate status (C20) in combination with conventional land cultivation) (Nehlsen, 2012). (b) Cultivation of corn with mulch seeding (photo: Brandhuber, LfL)

6 NEXT STEPS

As the KLEE project was launched recently still many tasks have to be performed in order to achieve the project goals. The next steps will be as follows:

- Establishing and implementation of the measurement and monitoring program
- Recalibration and extension of the existing numerical models
- Performance of the first learning and action alliance concerning field measurements

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