Guidance

Title: **Estimation of the impacts of climate change in a river catchment and determination of sustainable adaptation measures**							
Keywords: Climate change adaptation; integrated flood management planning; flood prevention; damage potential; cost-benefit analysis; conflict management; communication strategy							
Audience: Environment agencies; regional and local water managers and flood risk management professionals.							
Messages in the ESPACE strategy to which the guidance applies:	1. X	2.	3. X	4. X	5.	6.	7.X
	8. X	9. X	10. X	11. X	12.	13. X	14. X

Sentences linking the guidance to relevant strategy messages:

1. The guidance developed by LfU contains risk management processes in sustainability appraisals and strategic environmental assessments which can be implemented in regional Flood Management Plans (e.g. flood action plan “HAP” for the river Main).

3. The guidance developed by LfU uses risk management processes as well as cost-benefit analysis.

4. The guidance developed by LfU explains that in the evaluation and decision making process several organisations must work efficiently together.

7. The assessment of the options in spatial planning in relation to climate change is the main object of the guidance developed by LfU.

8. The guidance developed by LfU aims at finding adaptation measures which are most effective and efficient.

9. The estimation of reliable “climate change factors” for designing flood protection measures is the core of the process in the guidance developed by LfU.

10. The guidance developed by LfU enables a reliable definition of the limits of infrastructural flood protection taking climate change into account and the self protection measures that should be undertaken by the private sector and citizens.

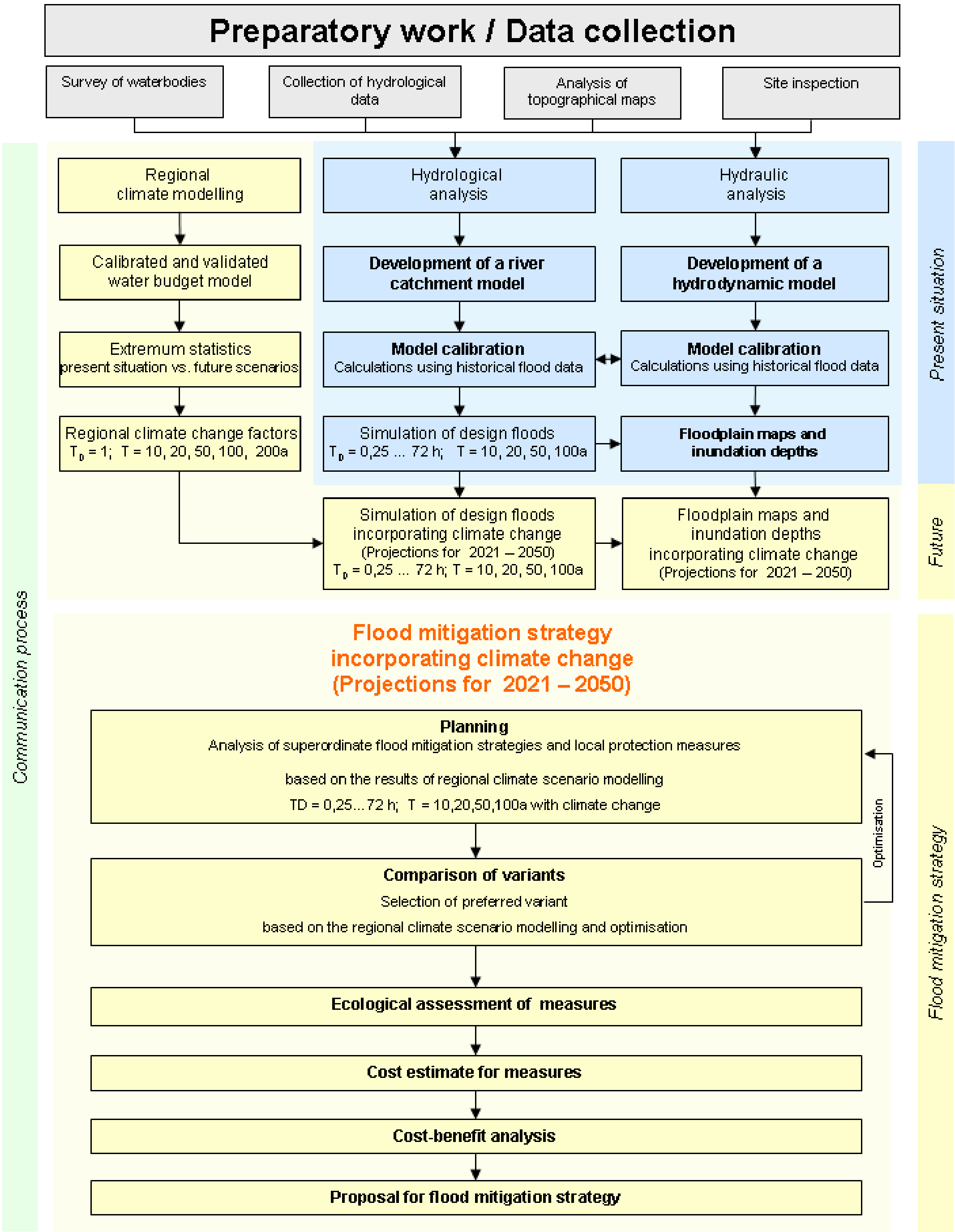
11. The guidance developed by LfU enables the development of long-term solutions by giving concrete decision support on the basis of cost benefit calculations and shows clearly vulnerable areas and assets on a mapped basis.

13. The guidance developed by LfU supports decisions and measures with long lasting influence and is therefore based on the principle of precaution and not on responses to experienced extreme events.

14. The guidance developed by LfU takes into account that climate change is a highly

dynamic process which is a commitment for the Bavarian water administration to carry out regular reviews and revisions.
Overview: The guidance should be used as a recipe and enables an estimation of the impacts of climate change in a catchment area and subsequently the finding of the most efficient measures for flood protection. The process starts with the development of quantitative information on climate change and the consequences for regional water budgets. It analyses the climate change related impacts on flood events and the resulting physical impacts on different land uses. Along with this the economic, ecological and socio-cultural impacts are assessed. The main result is the calculation of “climate change factors”. These are the basis for an analysis of effectiveness for the different planning options. The communication process with all parties involved accompanies every phase of the process and leads to an optimal mix of measures concerning mitigation and adaptation to climate change.

Diagram 2: Flow chart of the planning process integrating climate change



Description:

One result of the Bavarian work in the frame of the ESPACE project is detailed guidance for the estimation of the impact of climate change in a river catchment and subsequently the finding of the most efficient measures for flood protection taking climate change into account. Against this background, the Bavarian Environment Agency (LfU) approach is a holistic one with a special focus on the quantification of climate change effects on the river basin or sub-catchment level, considering:

- the physical impacts
- the economic impacts
- the ecological and socio-cultural impacts.

The most crucial part of this guidance is the step by step application of the procedure shown in Diagram 2, embedded in an appropriate communication strategy. This procedure can be used as a generic recipe.

The planning process follows the flow chart shown in Diagram 2. To estimate the quantitative impacts of climate change on water related issues, it is important to use the "with and without" principle, this means comparing the scenarios with and without climate change. The influence of climate change is estimated by the determination of the climate change factors (yellow boxes). The blue boxes describe the detailed analyses of hydrological and hydraulic characteristics of the river catchment. The combination of the results enables the calculation of the damage potentials with climate change (yellow). This is the input for cost-benefit analyses, on which decision-making has to be based.

1. Database
First of all, an adequate database is required to have a reliable foundation for the following steps. Essential data are for example surveys of the water bodies and the flood-prone valley areas, hydrological data, detailed topographical data and site inspections.

2. Processing:

a) Regional Climate Model:
As an optimum method has not yet been devised for development of regional climate models, different downscaling methods should ideally be applied to different GCMs (Global Circulation Models) based on various different emission scenarios, to produce a wide range of regional climate models. In a second step one regional climate model can be given preference above the others and supplies the input data for the following water balance modelling.

b) Water balance modelling and extreme value statistics:
Establishing water balance models for the existing climate conditions with measured climate data is a key prerequisite for the assessment of climate change impacts on water balance components. Model requirements are high: forecast models need a physically based process description. Extreme value statistics are used to derive flood discharges based on the outputs of water balance modelling. Characteristic flood events with different probabilities of occurrence are the key information for spatial planning in catchment flood management.

c) Hydraulic modelling and modelling of damage potentials
These calculations enable the estimation of:

- the physical impacts

- the economic impacts due to increased damage potentials
- the ecological and socio-cultural impacts.

Based on these results, the realisation of measures in the frame of 'Integrated flood management planning' with and without taking climate change into account is possible. One very important output in this context is the establishment of so called "climate change factors".

3. Estimation of the climate change induced increase in vulnerability and consequences for flood risk management

With the approach outlined above, it is now possible to get information on the increase in vulnerability due to climate change. The task to be solved is the consideration of the "with and without" case. The basic differences at the starting point of the process chain are the different hydrological characteristics. Aggravated flood conditions lead to a higher hydraulic load. Negative effects on land uses rise and therefore the damage potential grows.

What are the consequences resulting from the knowledge of increasing vulnerability to loads?

Many floods in recent years have demonstrated that technical infrastructure has its limitations. As flood risk management focused on natural retention effects plays a subordinate role in more extreme events, the optimisation of the measures to be deployed concentrates on the substitution problem between built infrastructure and further self-provision, i.e. up to what degree of protection can infrastructure measures be justified? As this essentially depends on the respective circumstances, situation-specific individual decisions are required. The economic efficiency facts play a key role in this. However, cost-benefit analysis is sometimes far away from good practice. Besides quality, the planning content should be based on the information required in the decision making and communication process in a transparent and clear way.

In the existing protection schemes the main emphasis is on the reliability of the constructions and their emergency facilities. The need for adjustment measures results from the requirements of recognised rules of sound engineering practice. A whole range of different situations can occur. The most favourable circumstances exist when the scheme can be retrofitted in an economically efficient way, both with respect to the safety standards to be guaranteed and with respect to the degree of protection that follows the principle of proportionality of means. The case in which the safety adjustment occurs at the expense of the degree of protection is substantially more unfavourable. The worst case is given, when, for reasons of efficiency, it is not possible to compensate for the increase in load due to climate change.

As the principle of proportionality of means ranks higher and higher there will be a strong need to foster further self-provision. This goes along with the communication of the residual risk which has been badly neglected in the past.

4. Communication strategy
In the past, public authorities put most emphasis on technical solutions, neglecting communication with the affected people. This led to underestimation of residual risks and limited communication on these subjects. Therefore, communication has to take place in every phase of the planning process and should be implemented in the flood protection plans.

The main overall objectives for the communication strategy are: raising awareness, change of behaviour, coordinated planning, implementation of optimal measures, cooperation.
In the frame of the application of the policies it is also important, to communicate in the context of climate change the limits of protection by technical infrastructure and to encourage a paradigm shift to an increased self-dependent precaution. This concerns the application of methods to raise awareness and change behaviour on climate change.

5. Outlook and conclusion

The evaluations provided give reasons to modify the method previously used to determine design runoff and, as a result of climate change, to consider a "load case climate change".

On the basis of practical case studies it has been proven that a consideration of the effects of climate change for technical flood protection measures would only have led to a relatively moderate cost increase in most cases, if this load case had already been taken into consideration during planning and if at least appropriate precautions had been taken into account during construction for later adaptation. Later adaptations, by contrast, mostly involve very high costs.

For this reason, when planning new flood protection measures in the future, the load case climate change should be examined. This should include the demonstration of the consequences of the load case for the measures being planned and which additional costs are expected as a result. Thus decisions have to be made, on the basis of available findings, to what extent the adaptation necessary for future climate change should already be taken into consideration in current work. The possibilities for additional later adaptation should also be taken into account.

This guidance shows how to calculate the "climate change factors" for the use of the load case climate change and how to use this information in the decision making process for effective and efficient flood protection measures.

Author:	Further information:
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