



Jul 1st, 12:00 AM

# A concept for the development of model indicators for policy makers to adapt German inland waters to climate change

Annette Stosius

Sebastian Kofalk

Michael Schleuter

Follow this and additional works at: <http://scholarsarchive.byu.edu/iemssconference>

---

Stosius, Annette; Kofalk, Sebastian; and Schleuter, Michael, "A concept for the development of model indicators for policy makers to adapt German inland waters to climate change" (2012). *International Congress on Environmental Modelling and Software*. 300.  
<http://scholarsarchive.byu.edu/iemssconference/2012/Stream-B/300>

This Event is brought to you for free and open access by the Civil and Environmental Engineering at BYU ScholarsArchive. It has been accepted for inclusion in International Congress on Environmental Modelling and Software by an authorized administrator of BYU ScholarsArchive. For more information, please contact [scholarsarchive@byu.edu](mailto:scholarsarchive@byu.edu).

# **A concept for the development of model indicators for policy makers to adapt German inland waters to climate change**

**Annette Stosius<sup>1</sup>, Sebastian Kofalk<sup>1</sup>, Michael Schleuter<sup>1</sup>**

<sup>1</sup>*Federal Institute of Hydrology, Departement U2 – Ecological Interactions  
Am MainzerTor 1, 56068 Koblenz, Germany  
stosius@bafg.de*

**Abstract:** Indicators are used for reducing complexity and for highlighting decision relevant topics and relationships. In response to actual transition processes currently taking place in the German inland waters management system, the objective of the research programme KLIWAS (Impacts of climate change on waterways and navigation - Searching for options of adaptation) is the assessment of climate-induced changes of flows and water levels, taking into consideration the uncertainties in climate projections. The main aspect of the indicator concept in KLIWAS is to translate relevant information to make it usable for policy makers. This necessitates a scientifically based formulation of indicators. The KLIWAS system approach and multi-model approach help to build this scientific base. We analyse user requirements and develop a concept for suitable indicators, mainly related to the ecological and economic issues of the maintenance of German inland waterways. This concept will support policy makers while assessing the efficiency of adaptation measures to manage the impacts of climate change. Therefore, the indicators are compared and contrasted with a set of decision-relevant parameters. The later set is derived from technical and administrative policy objectives for the operation and maintenance of waterways. We are also considering the existing legal requirements for river basin management. The models applied in the research programme will be analysed with regard to these indicators. The significance of the indicators will be evaluated, and requirements for the model development will be formulated. Our objective is to build an indicator concept which helps to answer the following questions: Where is the system of German inland waters impacted by climate change effects? What environmental and economic effects follow these possible impacts?

**Keywords:** indicators; climate change; maintenance of German inland waterways; system approach; multi-model approach

## **1 Introduction**

Actual transition processes taking place in the German inland waters management system are the implementation of the European Water Framework Directive (WFD) and the possible impacts on navigation and waterways by climate change. The WFD came into force in 2000 and was implemented in German law in 2010. Management of German inland waters is since then being expanded beyond just transport issues to water management issues including achieving and maintaining a good ecological status (or potential) and the ecological continuity of water bodies. The aim is an integrated river basin management with a focus on sustainable development. This also implies the consideration of possible climate change effects in future planning processes. Global climate projections anticipate

considerable changes in extreme weather conditions, in the oceanographic conditions (e.g. a rise in sea level) and in the inland water regime (IPCC, 2007). Based on the currently available global climate projections, far-reaching consequences for navigation, waterways, and the depending economy may be expected (ENVICOM task group 3, 2008). Policy makers therefore expect reliable statements on which adaptation measures need to be taken and when.

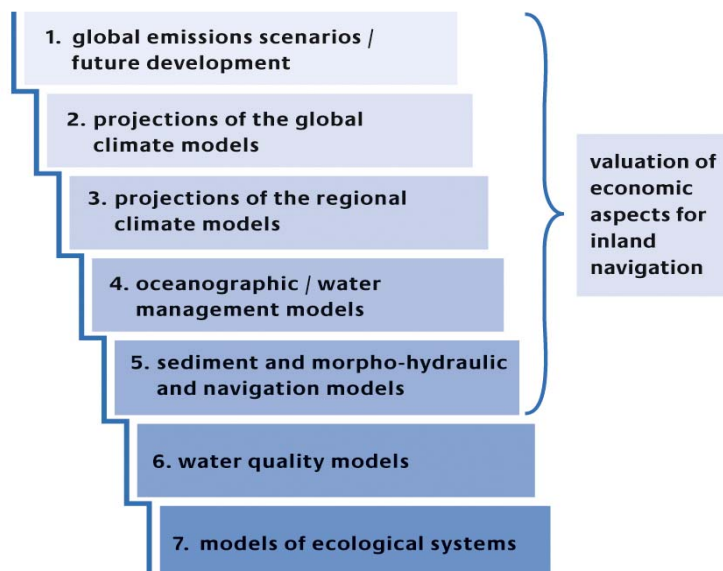
The purpose of the departmental research programme “KLIWAS – Impacts of climate change on waterways and navigation - Searching for options of adaptation” by the German Federal Ministry of Transport, Building and Urban Development (BMVBS, 2009) is to assess climate-induced changes of flows and water levels in navigable inland waterways. Other fields of interest are the range of such variations, their effects on the ecology of waters, the economic consequences - especially for navigation - and ultimately the identification of options to adapt to changes. The results are brought together as the KLIWAS indicators and these are able to help policy makers to transform into government action, while also enabling them to quantify the progress made in the transition process. We are also linking our work to the indicator concept of the German Strategy for Adaptation to Climate Change (Schönthaler et al., 2010). This strategy is based on the European White Paper on adaptation to climate change, which initiated another transition process in European countries.

How does one get well-grounded specific information about environmental problems, such as climate change, without getting lost in a huge amount of information? How does one choose the critical information, which is relevant for this inland water issue? Indicators can help, because they simplify complexity (Smeets and Weterings, 1999), since they point to certain topics representative for those issues concerned. Indicators may highlight the relevant relationships and help to communicate and evaluate. In relation to policy-making, (environmental) indicators are used for three major purposes (Smeets and Weterings, 1999):

1. to supply information on environmental problems;
2. to identify key factors that cause pressure on the environment;
3. to monitor the effects of policy responses.

## 2 Method

### 2.1 System approach



**Figure 1:** Model chain for the system oriented approach in KLIWAS (BMVBS 2009).

We base our indicator concept on the idea that there are starting impacts and various responding processes, including adaptation measures. We understand the system of German inland waters as an open system (see the Appendix), where climate change primarily affects precipitation, radiation and external inflows. Starting impacts are all direct results of changes, for example, in runoff processes, sediment balance or water temperature regime, which themselves impact other processes and so on. Furthermore, there are a number of feedbacks, so that a complex structure of impacts and reactions emerges. Adaptation measures in management functions are initiated from policy makers as reactions on the system changes.

Potential adaptation measures can only be evaluated when the complex system under investigation is fully analysed and well understood. Therefore, KLIWAS uses a system approach with a complex model chain (see figure 1), starting from global and regional climate models, via hydrological and morpho-hydraulic models, up to ecosystem and economic models. All models are already being used routinely or are being further developed for specific fields. They are an important tool to monitor the system "inland waterway" in all its parts concerning its vulnerability to climate change (BMVBS 2009).

## 2.2 Multi-model approach

The future evolution of climate and discharge will be the result of natural variability and current or future human impact. Neither aspect can be predicted precisely, but has to be estimated on the basis of two criteria (Nilson et al., 2012):

1. Different but plausible assumptions of human activity (i.e. socio-economic scenarios, greenhouse gas emission or concentration scenarios), and;
2. Different but plausible computer models that simulate climate variations that are a result of the influence of (1) and the current state of knowledge of climate dynamics (i.e. climate projections).

At each step of the model chain (described in section 2.1) future projections are derived and evaluated, uncertainties are assessed by the KLIWAS multi-model approach (Krahe et al., 2009, BMVBS 2009). By using a model ensemble instead of only one model, it becomes possible to assess the degree of robustness of climate change data. The term 'robustness' refers to the ability of the models to plausibly reproduce the main features of the observed climate in the 20th century and it refers to their conformity over a clear majority of projections. It must not be confused with 'likelihood' or 'probability', which by definition cannot be determined in a scenario-based study (Nilson et al. 2012). This approach provides at each step of the model chain a range of possible future outcomes, hence we can choose plausible scenarios for future development of the German inland waters.

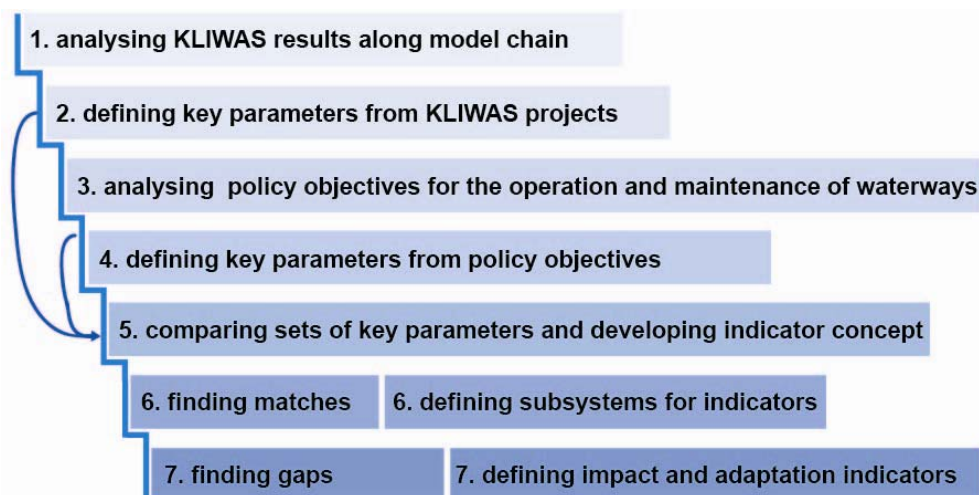
## 2.3 Indicator concept

A great variety of indicators already exist in for river basin management and for river basin research. Many of them are based on the DPSIR-Framework of the European Environmental Agency EEA (Smeets and Weterings, 1999; Wiggering and Müller, 2004; Walmsley, 2002; Harremoes and Turner, 2001). These typologies were designed as an analytical tool to display complex interactions and to analyse dynamic flows in systems (Morosini et al, 2001). DPSIR stands for: Driving forces and the resulting environmental Pressures on the State of the environment have Impacts resulting from changes in environmental quality and on (societal) Responses to these changes in the environment. Kristensen et al. (1999) describe it as a kind of „systems approach“. This level can be enlarged through indicators which depict progress and efficiency of targets and make them measurable, see the ABCD-scheme of the EEA (Smeets and Weterings, 1999). Over the last ten years however, many indicators are also in use that are not dedicated to a theoretical typology, but are only structured in action fields or subsystems (BLAG KliNa, 2010; Schönthaler et al., 2010; SRU, 2008; Statistisches Bundesamt, 2008 and 2010). This method lightens the handling of indicators

especially for external users who are not familiar with indicator theory, but want to use indicators for their specific issue.

The main aspect of the developed indicator concept in KLIWAS is to condense the relevant information into indicators and to make them usable for policy makers. Therefore, we reduce any theoretical background to a minimum. This enables a maximum of comfort for potential users. We follow the system approach used in KLIWAS and build groups of indicators according to the declared subsystems. We also subdivide our indicator concept in two categories: impact indicators and adaptation indicators (Stosius and Kofalk, 2012). The term 'impact' used in this connotation means not the same as in the DPSIR framework, we use this term wider, enclosing all influences into the system. The term 'adaptation' implies, on the one hand, ecological reactions of the natural system itself, and on the other, economy and policy related changes, i.e. adaptation measures and the building of adaptive capacity.

The set of indicators in this concept is based on two foundations. One is the main impacts and adaptations according to climate adaptation within the German inland waters system. The other is decision-relevant parameters in technical and administrative policy objectives as well as the existing legal requirements for German inland waters. The developing steps of the indicator concept are shown in figure 2.



**Figure 2:** flowchart to illustrate the steps to develop an indicator system for policy makers to adapt German inland waters to climate change.

### 3 Implementation so far and outlook

Within the KLIWAS research programme, we developed a preliminary system understanding of the German inland waters under climate change. Climate change may influence precipitation, radiation and external inflows. Starting impacts are all impacts coming directly from these changes, for example on runoff processes, sediment balance or water temperature regime. They are followed by various processes determined by starting impacts and the structure of the system, such as morphology, water quality or flora and fauna.

We use the results of the research groups working within KLIWAS to assess the key factors in the processes studied. They deliver an individual overview over their specific research theme by naming the main determining factors and parameters according to climate adaptation in their subsystems. We group them according to impacts or adaptation parameters.

The next step is to compare and contrast this set of parameters with the set of decision-relevant parameters. The later set is derived from technical and administrative policy objectives for the operation and maintenance of waterways. They are collected through literature studies and dialogues with policy makers also considering the existing legal requirements for river basin management. We

can show gaps and overlaps this way and find hints for possible lock-ins in the transition process to a sustainable river basin management of German inland waters.

One challenge on the way to a set of indicators is to translate the resulting parameters from the KLIWAS system analysis into plain language of policy makers. At the moment we are entering into a dialogue with the Federal Waterways and Shipping Administration to get a clear picture of their 'indicators' and parameters used in their operational work. This enables us to see if the preliminary research results of KLIWAS indeed meet the demands of the future users, and if not we can give hints to the working groups on how to modify their simulations.

Development has begun on our indicator concept. We are defining key parameters of the two foundations of the indicator concept and are comparing these sets of parameters (steps 2, 4 and 5 in figure 2). But we still have to fill gaps in the main impact and adaptation parameters for a complete view of the German inland waters system. We want to complete the set of indicators based on the two defined foundations of the concept so it will be capable of acting in the near future. Therein we have to take uncertainties into account depicted by the range of the model chain results.

## 5 Conclusions and Recommendations

Developing model indicators for policy makers to adapt German inland waters to climate change is a science and policy nexus for adapting to climate change and coping with transition processes. Our work helps to combine the KLIWAS results and the needs of policy makers.

The integrated KLIWAS approaches deliver a detailed system analysis and a well-grounded choice of model chains from climate and hydrological, morphological and ecological models to provide a range of potential future outcomes under climate change. The results of the KLIWAS research groups are analysed under the aspects of main impacts and adaptations within the German inland waters system.

The main aspect of the developed indicator concept in KLIWAS is to condense relevant information and to make it usable for policy makers. To this end we are developing a concept for suitable indicators, mainly related to ecological and economic issues of the maintenance of inland waterways. This concept will support policy makers to assess the efficiency of adaptation measures as they manage the impacts of climate change.

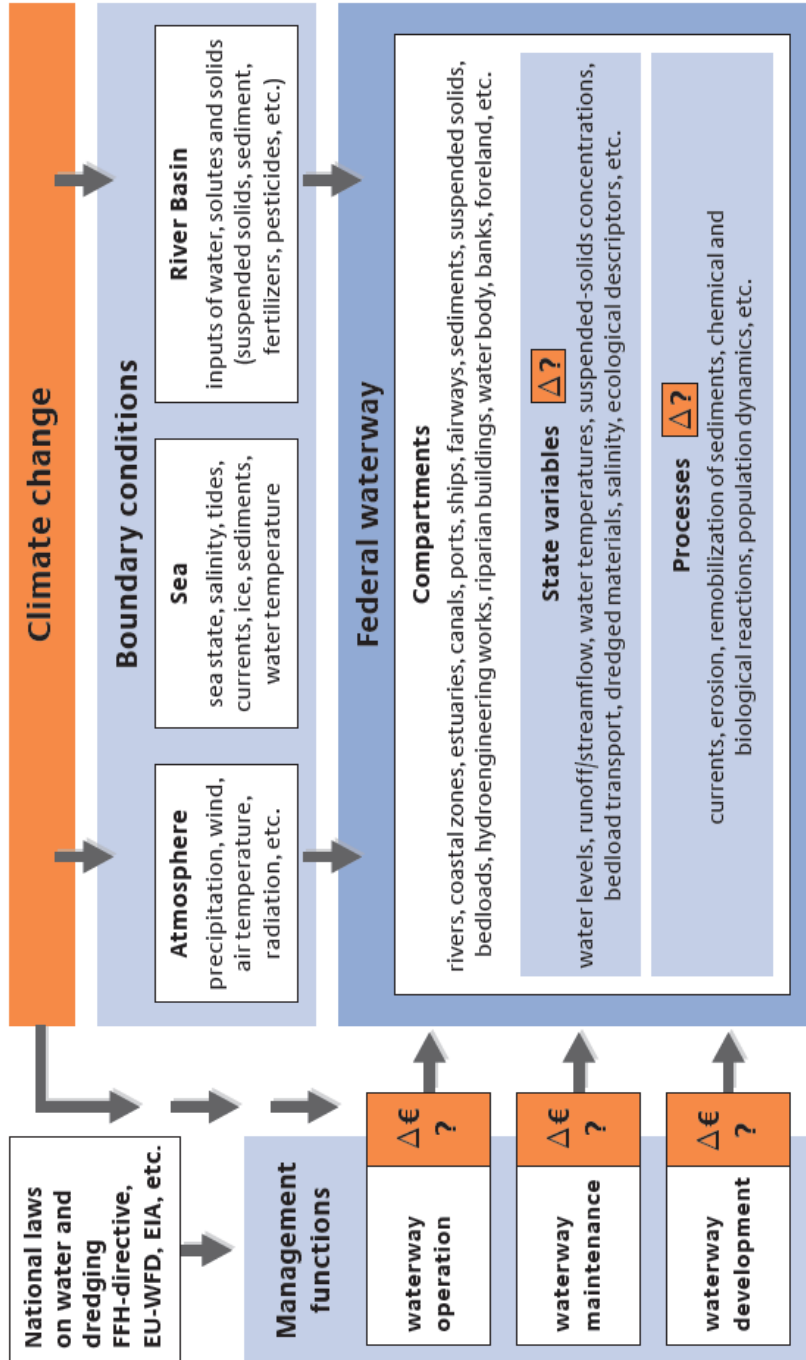
There is still work to do before we reach an applicable set of indicators. The concept needed as a basis to develop indicators is the first step. The next step is the full alignment of parameters derived from KLIWAS results with technical, administrative and legally binding parameters, followed by defining the indicators based on reliable expertise and data. The set of indicators may then help policy makers in the Federal Waterways and Shipping Administration but also other users to cope with challenges in transition processes, such as climate change. Moreover indicators can play an important role in the design of decision support systems. De Kok et al (2008) describe that internal consistency of models and data, effective communication, and functional flexibility are essential to warrant a proper balance between scientific standards, the availability of models, and the requirements of users. This facilitates the design process and improves the chance of successful implementation of decision support systems. This implies the necessity of a scientifically based formulation of indicators.

## REFERENCES

Bund/Länderarbeitsgemeinschaft Klima, Energie, Mobilität - Nachhaltigkeit (BLAG KliNa), 3. *Erfahrungsbericht 2010 zu umweltbezogenen Nachhaltigkeitsindikatoren*, 2010.

- BMVBS Federal Ministry of Transport, Building and Urban Development, *Navigation and Waterways in Germany – Meeting the Challenges of Climate Change. A Review*. Bonn, 2007.
- BMVBS Federal Ministry of Transport, Building and Urban Development, *KLIWAS – Impacts of Climate Change on Waterways and Navigation in Germany*. Conference Proceedings first KLIWAS-Status Conference 18 and 19 March in Bonn, Germany, 2009.
- de Kok J., S. Kofalk J. Berlekamp B. Hahn and H. Wind, From design to application of a decision-support system for river-basin management, *Water Res. Manag.* 23(9): 1781-1811, 2008.
- ENVICOM task group 3, Climate Change and Navigation - Waterborne transport, ports and waterways: A review of climate change drivers, impacts, responses and mitigation. PIANC EnviCom TG 3, Brüssel, 2008.
- Harremoes, P. and R. Turner, Methods for integrated assessment. *Reg. Env. Change* 2: 57-65, 2001.
- Intergovernmental Panel on Climate Change IPCC, *Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change* (Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K., Tignor, M., Miller, H. (eds.)). Cambridge University Press, Cambridge, UK and New York, USA, 2007.
- Krahe, P., E. Nilson, M. Carambia, T. Maurer, L. Tomassini, K. Bülow, D. Jacob, and H. Moser, Wirkungsabschätzung von Unsicherheiten der Klimamodellierung in Abflussprojektionen – Auswertung eines Multimodell-Ensembles im Rheingebiet. *Hydrologie und Wasserbewirtschaftung*. Heft 5/2009. S. 316-331, 2009.
- Kristensen P., L. Anderson, and N. Denisov, a checklist for state of the environment reporting. Technical report No.15, EEA, Copenhagen, 1999.
- Morosini M., *Umweltindikatoren – Grundlagen, Methodik, Relevanz. Band 1 Pilotstudie in drei Bänden ; Projekt: Relevanz von Umweltindikatoren*, Akad. für Technikfolgenabschätzung in Baden-Württemberg, 2001.
- Nilson, E., P. Krahe and K. Görgen, Climate Projections for the Greater Alpine Region - An evaluation of selected regional climate simulations with respect to hydrometeorological variations. Bericht BfG-1749, Bundesanstalt für Gewässerkunde, Koblenz, 2012.
- Sachverständigenrat für Umweltfragen SRU, *Umweltschutz im Zeichen des Klimawandels*. Erich-Schmidt-Verlag, Berlin, 2008.
- Schönthaler, K., S. von Andrian-Werburg, K. Wulfert, V. Luthardt, B. Kreinsen, R. Schultz-Sternberg and R. Hommel, Establishment of an Indicator Concept for the German Strategy on Adaptation to Climate Change. UBA-Texte 07/2010, UBA-FBNr. 001416/E, Umweltbundesamt Dessau, 2010.
- Smeets E. and R. Weterings, Environmental Indicators: Typology and Overviews. Technical Report No 25. European Environmental Agency – EEA, Copenhagen, 1999.
- Statistisches Bundesamt, *Nachhaltige Entwicklung in Deutschland. Indikatorenbericht 2008*. Wiesbaden, 2008.
- Statistisches Bundesamt, *Nachhaltige Entwicklung in Deutschland. Indikatorenbericht 2010*. Wiesbaden, 2010.
- Stosius, A., S. and Kofalk, Entwicklung eines Indikatorensystems für das System „Binnenwasserstraße“ und für politische Entscheidungsprozesse bei der Anpassung an den Klimawandel. Poster contribution to „Tag der Hydrologie“ 22.-23.3.2012 in Freiburg, Germany, 2012.
- Walmsley, J., Framework for measuring sustainable development in catchments systems. *Environ. Managem.* 29(2): 195-206, 2002.
- Wiggering, H. and F. Müller (eds.), *Umweltziele und Indikatoren : wissenschaftliche Anforderungen an ihre Festlegung und Fallbeispiele ; mit 32 Tabellen*. Berlin u.a., Springer, 2004.

APPENDIX



The system approach implemented in KLIWAS. The amounts of change marked in orange are currently under investigation and serve as basis for the development of indicators (BMVBS 2007).