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Title: **Planning Nature-based Solutions: Principles, Steps, and Insights**

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Table S1: Short description of methods used in the Lahn river landscape case study

Method	**Brief description and references**
Expectation management	Expectation management was practiced throughout the collaboration in terms of bilateral conversations between the project coordinators and workshop participants and scientists. For instance, participants were explicitly asked about their expectations before the workshop to identify interests and to clarify possible misunderstandings. Furthermore, a brief survey was conducted at the end of each workshop to learn from experiences made and to improve the design and execution of following workshops.
Stakeholder analysis	Aim of a stakeholder analysis is to learn, which stakeholders are the most relevant for the project's purpose. Descriptive approaches like the ones we used have a phenomenological orientation and look at the stakeholders and their interrelations. Characteristics of stakeholders were identified and described and resulting information could be used as input for normative and instrumental approaches (Kimmich et al. 2012; Reed et al. 2008).
Individual interviews	Individual semi-structured interviews were conducted to obtain information about individual perspectives like aims, interests or intentions. For a better comparability we used an interview guideline that contained different thematic blocks with related questions. These can be derived from a theory or lead to the generation of a theory. The analysis of the empirical material gained in the interviews included a two-step coding, following the analytical methods of theoretical coding by Strauss and Corbin (1990).
Social network analysis (SNA) with participatory Net-Map tool	The Net-Map tool is a tool for mapping actors' networks. It detects the important actors in a network and distinctive relations between them by applying four interview steps: 1) recording the influencing actors, 2) identifying links between actors, 3) identifying actors' interests/motivations, and 4) assessing the actors' influence on the network. The data gathered can be used for social network analysis (Hauck and Schiffer 2012).The method has been applied to characterize the network of the LiLa-project partners.
Online public participation geographic information system (PPGIS) survey	PPGIS methods are able to elucidate spatial (and non-spatial) information of local citizens or non-experts to understand the social and cultural landscapes (Brown and Kyttä 2014). In our case study respondents located activities and meaningful places in and around the Lahn river. This information (and thus the voice of the local citizens) was used to support planners or decision makers (Raymond et al. 2014; Gottwald et al. 2020).
Focus group discussion	Focus group discussions in combination with participant observations are used for bringing relevant actors together in order to discuss different perspectives, learn from each other and for the researcher to identify

	group dynamics and interrelations in a more natural conversation framing. Participants can learn from each other through the exchange of experiences, while scientists can provide results relatively quick by talking to several people at once about a certain topic. The method produces data and insights that would be less accessible without interaction found in a group setting that stimulates experiences, ideas and memories by listening to others (Lindlof and Taylor 2002).
Ecosystem services survey	An online survey was conducted amongst local stakeholders to learn about their involvement and the involvement of others on collaboration networks for the co-production of twelve ecosystem services. The data was analyzed with SNA to construct the networks and understand some differences between opposite perspectives. SNA examines social structures using networks and graph theory. Network structures are calculated and visualized according to nodes (actors) and the ties, edges, or links (relationships or interactions) that connect them (Prell 2011).
Development of a nature-based solutions (NBS) catalog	A database was developed containing information on potential NBS for river landscapes (Schmidt et al. in prep). For each of the 646 NBS information was collected on the definition of the NBS, application area, ecological impact, and associated changes in ecosystems services. Also, NBS were assigned to the standardized classification system for generic measures to improve conditions of river landscapes used by the German Working Group on water issues of the Federal States and the Federal Government (LAWA) for the development of action programs and subsequent reporting to the European Commission's Water Information System Europe (WISE) (LAWA 2015). The database content on NBS was compiled through a scoping review (Grant et al. 2009, Tricco et al. 2018) in Web of Science, and grey literature.
Linking local Sustainable Development Goals (SDG) and NBS	For the identification of NBS that contribute to achieve local SDG a qualitative content analysis (Stemler 2001) of development goals in the Lahn river landscape (Best et al. 2019) and the United Nations SDGs (United Nations General Assembly 2015) was conducted. Based on this analysis content-related similarities and differences of development goals were identified (Schmidt et al. in prep). Similar Lahn development goals and SDGs were then linked with NBS according to NBS's major ecological impact and resulting contribution to achieve the development goals. For this step the NBS catalog (see above) was used as well as the classification system developed by Fribourg-Blanc et al. (2015) that determines potential ecological changes due to NBS.
Mapping NBS opportunity spaces	Inspired by hydrological models, which work with delineated hydrological response units, this method is based on hydromorphological landscape units (HLU) which are comprised of specific biophysical spatial criteria to identify potential areas that could function as NBS (Kalcic, Chaubey and Frankenberger 2015; University of Texas A&M 2012). The HLU approach was tested for selected floodplain-related NBS in the Lahn river landscape (Guerrero et al. 2018). Results showed the location and spatial extent of both existing NBS areas and potential areas for NBS

	implementation. The HLU can be used as an initial approach to support NBS planning and implementation.
Participatory scenario development	Implementing NBS at the landscape scale would be a long-term and collaborative effort. Planning with NBS can thus be usefully supported by participatory scenario development. The PlanSmart project applied an exploratory scenario exercise in which the future context conditions were envisioned as a combination of two key drivers: the level of consideration of ecosystem processes in river management, and the governance context (ranging from entirely market-driven to more state-controlled). The combination of those two drivers opened up four quadrants which were subsequently jointly developed into storylines and hand-drawn visualizations of how the future landscape might look like. Participants were further asked to choose between a handful of roles (in terms of characters such as a farmer or journalist) and were exposed to a time travel-exercise to support an engagement with potential futures and an open-minded exploration of potential and plausible future scenarios.
Geodesign	Geodesign can be defined as 'a design and planning method, which tightly couples the creation of design proposals with impact simulations informed by geographic contexts, systems thinking and digital technology' (Steinitz 2012, p. 12). Geodesign provides useful tools and methods to facilitate participatory planning, manage boundaries between participants, and assess impacts of NBS. The Geodesign process was implemented in PlanSmart as a workshop consisting of five steps to co-develop and explore spatial scenario maps in consideration of NBS. The steps included (i) a recap of scenario stories developed in a prior workshop, (ii) scenario sketching, (iii) allocating land uses, (iv) exploring impacts, and (v) reflecting.
Extended peer review for evaluation of localized NBS	Extended peer review is the involvement of non-academic actors in the quality assurance process of knowledge generation (Funtowicz et al. 2015). By using additional knowledge from stakeholders localized NBS can be evaluated and scenarios for landscape planning prioritized. In PlanSmart an extended peer review was conducted in a one-day workshop involving nine representatives from local to national, governmental authorities responsible for Lahn development strategies and actions (Schmidt et al. in prep). The workshop was structured as follows: i) Briefing on topic and tasks through informative presentation of scientific findings (localized NBS) and introduction of quality assurance tasks; ii) evaluation of the quality of the scientific work and documentation of explicit value judgements by peers through open round table discussions and interactive GIS-based approaches; iii) reflection of results through discussions and revision of evaluation results.
Governance model database analysis	Although co-designing governance or business models for implementation was not possible in the scope of the case study, a database of successful NBS projects on similar issues within Germany was developed. The database was used to identify determinants of success and clusters of combinations of variables that together provide

	inspiration for designing place-specific governance models (Zingraff-Hamed et al. in review).
Planning document analysis	Planning documents can be considered outcomes of decision-making processes. They contain information on the discourse of specific challenges, measures, planning processes and decision practices at a certain point in time. A document analysis aims to capture and analyze the contents of planning documents to reconstruct past planning processes, and adapts methods of qualitative and quantitative content analysis (Brillinger et al. 2020).
Multi-criteria analysis (MCA)	MCA is an umbrella term to describe a set of approaches that can be applied to structure and inform decision-making. The basic idea of MCA methods is to evaluate the performances of alternatives (e.g. management options) with respect to criteria that capture the key dimensions of the challenge (e.g. ecological, social, and economical criteria), involving human judgments and preferences. MCA commonly include (i) problem structuring that defines alternatives and evaluation criteria, (ii) criteria evaluation that assess the performance of each alternative with respect to multiple criteria (scoring) and attaching the importance to the criteria (weighting), (iii) application of an aggregation rule that combine criteria scores and weights to derive overall values of each alternative, and (iv) actual decision on the suitability of alternatives (Adem Esmail and Geneletti 2018). The combination of an MCA with participatory and deliberative elements is useful in dealing with the plurality of values and beliefs held by stakeholders on certain types of challenges. MCA should be as participative and transparent as possible to increase the relevance for the stakeholders and legitimacy of the evaluation process (Greco and Munda, 2017).
Spatial assessment of ecosystem services, also as co-benefits of NBS	Spatial assessment of ecosystem services is a geographic analysis and valuation which seeks to explain patterns of nature's contribution to human well-being and its spatial evidence. In collaboration with PlanSmart the River Ecosystem Service Index (RESI) was applied for spatial assessment of ecosystem services in the Lahn river landscape. The RESI is an assessment approach for quantitative valuation and spatial explicit mapping of 16 ecosystem services of river landscapes including provisioning (e.g. crops, plant biomass), regulating (e.g. flood regulation, nitrogen retention) and cultural ecosystem services (e.g. landscape aesthetic, water-related activities) (Podschun et al. 2018). In the RESI ecosystem services are defined by spatial indicators that represent major socio-ecological conditions of the river landscape. For each of the indicators spatial data and a GIS for data processing is required. Outputs of RESI are standardized into a five-tier scale to enable integrative valuation and summary across different river segments. By assessing the RESI before and after the implementation of NBS, or scenarios of different NBS, the impact on ES can be estimated and planning alternatives discussed (Podschun et al.2018).

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BOX S1: Information on scoping review

The scoping review and synthesis of the best available knowledge regarding the framework of planning NBS considered all relevant literature that could be found by a dedicated query in , performed on November 6, 2019. In our search query title, abstracts and keywords of publication were screened for the following search terms: 'principle* OR criteria OR criterion OR characteristic* OR implication* OR strategy* OR guideline* OR guide* OR standard* OR basis OR rule* OR require* OR law* OR framework* AND "nature-based solution*" OR "nature based solution*'. We identified 238 publications and discarded 179 after thoroughly reviewing titles and abstracts. Studies that used NBS only as buzzword without detailed information on NBS or NBS planning were excluded. For the remaining 59 publications, full text reviews were conducted. Additionally, two frequently cited policy reports (European Commission 2015; and Cohen-Shacham et al. 2016) were included.

Table S2: Literature included in synthesis and refinement of the framework for planning NBS.

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