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Advancing Sustainable Development Goals with localised nature-based solutions: Opportunity spaces in the Lahn river landscape, Germany

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ABSTRACT

Nature-based solutions (NBS) are recognized as promising actions to alleviate societal challenges and achieve the United Nation's Sustainable Development Goals (SDGs). One scientific challenge to implement NBS in practice is to locate areas suitable for an effective implementation of NBS (opportunity spaces). Opportunity spaces either already host NBS that need to be safeguarded or restored, or provide the socio-ecological conditions for establishing new NBS. Complex methods have been proposed to model potential locations of selected NBS, but they are often too data and resource intensive to be applied in practice for landscape planning. The aim of this article is to put forward a pragmatic method for identifying NBS opportunity spaces that contribute to advance multiple SDGs, and to test its application in a participatory, extended peer-review process in the Lahn river landscape, Germany. Our method includes: (i) synthesizing a generic catalogue of NBS in river landscapes, (ii) estimating the potential of NBS to achieve simultaneously Lahn development goals (LDGs) and SDGs, and (iii) applying key spatial indicators and best available data to explore opportunity spaces for selected NBS. The generic catalogue provides a systematic overview of 650 individual NBS for river landscapes and their respective potentials for addressing LDGs and SDGs. The NBS *Renaturalising floodplains through land use changes*, *Revitalising historic floodplains*, and *Creating buffer strips* are those actions contributing to the greatest number of local SDGs (locally adapted SDGs that include LDGs). Results of the spatial analysis in the Lahn river landscape showed about 4739 ha of areas where NBS were already in place and need to be safeguarded and additional 1323 ha with opportunities for further NBS creation. The proposed method presents a robust and transferable approach that facilitates spatial mapping of NBS to local SDGs for planning practitioners facing time and resource constraints.

1. Introduction

In 2015, 193 Member States of the United Nations General Assembly agreed upon the 2030 Agenda for Sustainable Development and its SDGs (United Nations General Assembly, 2015). The SDGs aim to shape the global future course of actions to meet societal challenges such as reduction of poverty and inequality, promotion of peace, justice and well-being, while considering resource limitations and environmental conservation. Despite criticism on the sustainable nature of the SDGs (Kopnina, 2016) and its workability (Norton and Stuart, 2014; Easterly, 2015), the implementation of SDGs started worldwide in 2016 in the so-called process of localising SDGs (United Cities and Local Governments, 2014). Localisation of SDGs is described as the process of considering sub-national contexts in the achievement of the 2030 Agenda, from the setting of goals and targets to determining the means of implementation and monitoring (Global Taskforce of Local and Regional Governments et al., 2016). Experiences from former global development goals (United Nations, 2000; Convention on Biological Diversity, 2000) and multi-stakeholder consultations (Tosun and Leininger, 2017; Division of Sustainable Development Goals, 2019) showed that the integration of local needs, priorities and expectations as well as local capacities to promote integrated, inclusive and sustainable development are the most critical factors that determine the success in reaching the SDGs (United Cities and Local Governments, 2019). Increasingly, efforts are underway to downscale the global SDGs into local actions (Global Taskforce of Local and Regional Governments, 2020; Rosato et al., 2021). However, debates still continue on how to prioritize SDGs taking account of interactions between SDGs as well as different local conditions, capacities, and capabilities (Scott et al., 2015; Pradhan et al., 2017; Bebbington and Unerman, 2018; Swain, 2018;

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Scharlemann et al., 2020).

NBS, an umbrella concept that summarizes sustainable practices which harness ecological processes to address societal challenges and provide simultaneous benefits for society, the economy and nature, offer a potential measure to meet multiple SDGs on a local scale (Dudley et al., 2017; Griscom et al., 2017; Acharya et al., 2020). Most NBS are anchored at a local level and embody essential principles of implementing the SDGs (Cohen-Shacham et al., 2016; United Nations World Water Assessment Programme, 2018). One principle comprises the issue: 'One goal cannot be achieved at the expense of any others.' (Le Blanc, 2015). For instance, NBS for river restoration meet water resources management challenges, as reflected in the SDG 6: 'Ensure availability and sustainable management of water and sanitation for all' (United Nations World Water Assessment Programme, 2018). Contributions of river restoration to ensure water availability translate into further positive impacts on other SDGs such as food security (SDG 2), healthy lives (SDG 3), building resilient (water-related) infrastructure (SDG 9), sustainable urban settlements (SDG 11) and disaster risk reduction (SDG 11, 13). Further co-benefits may address the protection of ecosystems and biodiversity (SDG 15), ensure access to affordable, reliable, sustainable and modern energy (SDG 7) and reinstate positive feedbacks between economic growth and environment (SDG 8) (United Nations World Water Assessment Programme, 2018).

NBS are increasingly recognized in international policies (Seddon et al., 2020) and promoted by the European Commission and the International Union for Conservation of Nature (Faivre et al., 2017; Seddon et al., 2019). Over the last decade NBS became more concrete and operational for local practitioners (International Union for Conservation of Nature, 2020; Albert et al., 2020; European Commission, 2021a). The list of what can be considered as NBS is long (Sutherland et al., 2014) and independently verified and comprehensive reviews of the evidence base on the (cost-) effectiveness, and applicability of different NBS for given contexts, scales, and locations are rare (Natural Water Retention Measures, 2014; Raymond et al., 2017; de Jesús Arce-Mojica et al., 2019; Chausson et al., 2020). This causes confusion in terms of what are effective NBS that fulfil basic tenets of sustainability and contribute to attain SDGs, and where are opportunity spaces representing suitable locations to safeguard and create new NBS.

The objective of this article is to put forward a pragmatic method for identifying NBS opportunity spaces that contribute to advance multiple SDGs of local priority (local SDGs), and to test its application in an extended peer-review process in the Lahn river landscape of Germany. More specifically the following research targets were addressed:

1) To provide a systematic overview of NBS in river landscapes,
2) To identify local SDGs as stipulated by planning documents, stakeholders and citizens,
3) To explore the potential contributions of NBS to advance local SDGs, and
4) To map opportunity spaces for implementing key NBS in the case study area.

We focused on NBS for river landscapes, because: i) river landscapes are precious as they provide a high variety and quantity of ecosystem services, they are amongst the most species-rich habitats, and belong to the most threatened ecosystems worldwide (Tockner and Stanford, 2002; Vörösmarty et al., 2010); ii) they have historically served for multiple, interdependent human uses in a cross-sectoral and cross-border political setting highlighting the need for integrative solutions instead of sectoral narrow-focused actions (Lee and Dinar, 1995; Moss and Monstadt, 2008; Schindler et al., 2016); iii) water is at the heart of the SDGs recognized as cross-cutting most social and economic aspects of the SDGs and, therefore, NBS to river landscapes translate into benefits and co-benefits for multiple SDGs (United Nations World Water Assessment Programme, 2018).

The article is structured as follows. First, the different steps of the method are described regarding how NBS for river landscapes and local SDGs were identified and linked; as well as how opportunity spaces were mapped and evaluated. Second, results are shown for selected examples of NBS that potentially advance most of the local SDGs. Third, implications of the choices made to apply each step of the method are critically discussed. Finally, conclusions are drawn and future research opportunities summarized.

2. Methods

In relation to the research targets, we developed a research design consisting of five major steps (Fig. 1).

2.1. Developing a NBS catalogue for river landscapes

In step one, a scoping review of scientific and grey literature on NBS was conducted to develop a catalogue of NBS for river landscapes. While a standardized approach for conducting scoping reviews does not exist (Colquhoun et al., 2014), the guideline of Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR, Table S2.1) was used (Tricco et al., 2018). In accordance with PRISMA-ScR bibliographic databases, such as Web of Science and Scopus, were searched for publications with 'nature-based solutions*' in the title to obtain a comprehensive overview of studies potentially holding information on NBS (Fig. S1). For a list of studies considered see Table S2.2. After correcting for duplications that occurred in both databases (78 studies) and unavailable publications (full text of 14 studies not accessible) a full text assessment for 87 studies was conducted. Detailed information about specific NBS for river landscapes was contained in 32 studies. Study selection and data extraction from the finally considered studies was based on an a priori standardized coding template and two reviewing authors of this article. The authors independently selected and extracted information on NBS. Any disagreements were resolved through discussion between the two authors or further adjudication by the third author of this article. Additionally, grey literature of collections of NBS was included based on the knowledge of the authors of this article (Table S2.3). The purpose of the study was not to create a complete database of NBS, but rather to provide a first overview of the diversity of existing NBS for river landscapes. To summarize and visualise results, NBS were grouped in accordance with a standardized classification system of generic types of actions that cover the main water management challenges of the EU (EU Key Types of Measures). The EU Key Types of Measures are used for national and international reporting of actions applied on the ground to achieve environmental goals of European directives such as the European Water Framework Directive (European Commission, 2015a; LAWA, 2020).

2.2. Identifying local SDGs in the Lahn river landscape

In step two, a qualitative content analysis of LDGs and the SDGs was conducted to identify local SDGs (Stemler, 2001; Krippendorff and Bock, 2009). See Table 1 for an overview of LDGs and SDGs.

The LDGs are the outcome of a two years participation process for the creation of an integrative Lahn development concept, in which different groups of stakeholders in the Lahn river landscape were formed (see Table S2.4) and group-specific development goals were determined (IKU, 2018b; IKU, 2018c; IKU, 2018a; Best et al., 2019). In the content analysis a total of 153 LDGs as well as 17 SDGs were considered. Summaries of the LDGs and SDGs were shown in Table 1. Major steps of the content analysis applied included: first, a thorough perusal of documents and connotations of LDGs and SDGs (United Nations General Assembly, 2015; IKU, 2018b; Best et al., 2019); second, the comparison of contents from different development goals including the identification and assignment of similar topics across LDGs and SDGs to determine local SDGs; and third, the review process to minimize the scope of interpretation and avoid incorrect assignments. For the latter, two of the authors

Box 1
Application case Lahn river landscape.

The Lahn river, located in the German federal states North Rhine-Westphalia, Hesse and Rhineland-Palatinate, has been significantly altered particularly from its confluence the Rhine up to the city of Gieβen for multiple reasons, including urbanisation and the usage as a federal waterway for navigation. Nowadays, the Lahn is no longer used for cargo navigation, yet, the maintenance of technical infrastructure, such as weirs and sluices, requires substantial investments. Moreover, a poor ecological water quality (Teusch and Maltzan, 2019) and conflicting interests of different stakeholder groups on renaturation efforts, settlement development strategies, passenger shipping and recreation opportunities (Henze et al., 2018) may benefit from the exploration of new solutions such as NBS for addressing the emerging challenges. Based on this background the EU LIFE project 'LiLa Living Lahn' was initiated with the aim to create an integrated development concept for the Lahn region that takes into account the different interests of water users, nature conservation and tourism associations, administrations from different sectors and levels as well as the local people (Living Lahn, 2014). The LiLa project is accompanied by the 'PlanSmart' research project (Albert et al., 2019, 2020) which focusses on innovative approaches for planning and governing NBS. This research article was developed within the PlanSmart project.

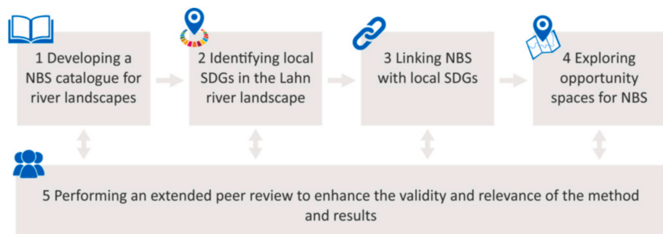

Fig. 1. The diagram shows the five major steps of the method applied in this article.

of this article analysed independently the same development goals and compared their findings. Disagreements were resolved through discussion between the two authors or further adjudication by the third author of this article.

2.3. Linking NBS with local SDGs

In step three, the contribution of NBS to local SDGs were drawn based on a qualitative content analysis of NBS's major ecological impact, associated changes in ecosystem services and links to policy goals. Major source of the content analysis was the report Natural Water Retention Measures (2015). In the report 38 NBS, their ecological impacts, effects on ecosystem services and generic policy goals were evaluated based on qualitative literature reviews and expert opinions. This information was adopted and qualitative linkages between NBS from the catalogue and local SDGs determined. Then the influence of each NBS on different local SDGs was counted. The top three NBS that potentially contribute to advance most of the local SDGs were selected for exploring NBS opportunity spaces (step 4). The selected examples of NBS included:

- *Renaturalising floodplains through land use changes,* focus on the conversion of agricultural used areas with a high risk of flood (MHW) into alluvial forest, floodplain meadows and grasslands.
- *Revitalising historic floodplains*, aims to reconnect historic floodplains with active floodplains and the flood regime of the Lahn river.
- *Creating buffer strips,* aims to establish areas for natural ecological succession and natural river bank development.

2.4. Exploring and mapping opportunity spaces for NBS

In step four, the spatial heterogeneity of socio-ecological systems and the need to adapted NBS to specific local conditions that may influence the impact of the NBS or even prevent their implementation was considered to explore and map opportunity spaces for NBS. Opportunity spaces for NBS were mapped based on a set of spatial key indicators that represent major local conditions (Harms et al., 2018; Bischoff et al., 2018). These indicators were differentiated according to their meaning for spatial mapping of NBS into two groups: exclusion and prioritization criteria. Exclusion criteria encompass indicators that impede the spatial mapping of NBS, such as residential buildings, bridges, highways and railway lines. Prioritization criteria represent indicators that address the evaluation and ranking of an area in accordance with their importance and urgency to implement specific NBS, for instance flood-prone areas. In total, we found seventeen indicators from which seven exclusion criteria and eight prioritization criteria were used for the mapping of opportunities spaces (Table 2). Two of the indicators were discarded due to missing geo-data. For none of the selected NBS, the data was sufficient to identify opportunity spaces along the entire Lahn river landscape. Most geo-data were available for *Revitalising historic floodplains* (77% of river landscape, from Cölbe to river mouth). For the NBS *Renaturalising floodplains through land use* (58%, from Gieβen to river mouth) and *Creating buffer strips* (68%, Hessian part of the Lahn river) shorter river sections were considered. Maps were constructed within ArcGIS 10.7 by using basic operations of the standard ArcToolbox for data management and spatial analysis of the indicator's geo-data from official sources (Table 2).

2.5. Performing an extended peer review to enhance the validity and relevance of the method and results

In step five, an extended peer review was conducted to evaluate opportunity spaces for the three selected examples of NBS and the spatial indicators applied for their mapping. Extended peer review is the involvement of non-academic actors and practitioners in the quality assurance process of knowledge production (Funtowicz and Ravetz, 2015). By additionally involving non-academic actors and practitioners the robustness of methods and results can be improved and their relevance for the application on the ground increased (Refsgaard et al., 2007). An extended peer review was conducted in a one-day workshop with nine non-academic actors and practitioners. The participants were recruited in an open invitation to the consortium of the LiLa project, with whom the authors had established a longer-term collaboration (see Box 1). The institutions in which the participants are employed represent the perspectives of nature conservation, river management, and general public administration at city, county, federal state or national levels. The workshop included presentations about the findings from working steps one to four, followed by round table discussions. Round table discussions were subdivided into two stages. First, non-academic actors and practitioners were asked to evaluate spatial indicators used for the determination of the opportunity spaces for the three selected examples of NBS and add further missing indicators important for their mapping. Spatial indicators were evaluated in the context of socio-ecological importance to map NBS (very important, important, not important) and level of feasibility to apply the indicators (easy, medium,

Table 1
The table presents a summary of the 153 LDGs into 31 groups as well as the 17 SDGs considered in this study. Also, the table works as a legend translating code numbers and colour codes of LDG groups used in the following figures of the article.

Code	LDG groups	SDGs
#1	Introduction of coherent strategies for implementation of and compliance with legal obligations from European, country and federal state level	End poverty in all its forms everywhere
#2	Improve Lahn water quality	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
#3	Enable longitudinal connectivity for humans and fauna	Ensure healthy lives and promote well-being for all at all ages
#4	Establish sustainable recreational activities and opportunity spaces for those activities in the Lahn landscape	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
#5	Improve structural elements of riverbanks, streams and drainage dynamics	Achieve gender equality and empower all women and girls
#6	Manage invasive species and protect endangered and indigenous species	Ensure availability and sustainable management of water and sanitation for all
#7	Evaluate intensity of use (all types) and their impact on the ecological status of the Lahn river landscape	Ensure access to affordable, reliable, sustainable and modern energy for all
#8	Implement integrative approach for ecological use of the Lahn	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
#9	Protect against flooding	Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
#10	Strengthen environmental awareness	Reduce inequality within and among countries
#11	Enhance attractiveness of Lahn for residents, tourists and companies	Make cities and human settlements inclusive, safe, resilient and sustainable
#12	Manage river landscape in accordance with economic principles	Ensure sustainable consumption and production patterns
#13	Stop additional land consumption	Take urgent action to combat climate change and its impacts
#14	Improve the habitat network	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
#15	Establish a site-adapted forestry and agricultural management within river buffer strips	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
#16	Reward and compensation for nature-friendly activities	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
#17	Create large-scale river corridors for ecological development	Multi-stakeholder partnerships
#18	Enhance ecological quality of water storage areas	
#19	No deterioration of current water quality	
#20	Provide adequate financial and personal resources	
#21	Develop integrative and sustainable access strategies for people to Lahn	
#22	Co-design an integrated development concept for the Lahn river landscape	
#23	Provide a central information system on the Lahn river status and trends	
#24	Enhance interventions for safety precaution of water traffic	
#25	Develop ecologically and economically sustainable infrastructures	
#26	Establish a decentralised energy generation system	
#27	Restore natural river banks	
#28	Preserve river banks from artificial constructions and fixations	
#29	Enable species migration	

complex) in practice for landscape planning. The latter includes finding accessible data of sufficient quality. Second, interactive maps on touch-tables showing GIS maps of spatial indicators and the resulting opportunity spaces were provided to collect feedback about the validity of the spatial location of opportunity spaces of each of the three examples of NBS. Interactive maps enabled spatial explicit feedbacks from non-academic actors and practitioners by allowing them to interactively draw or add their responses into the GIS maps in real time (ESRI, 2010). Inspired by the spatial maps, non-academic actors and practitioners also had the opportunity to reconsider and change their feedbacks from the first stage. At the end of the workshop, the method's relevance for the application in the Lila project and support of the elaboration of an integrated development concept for the Lahn region was evaluated by a rapid survey (see Table S2.5).

3. Results

3.1. NBS catalogue content

The catalogue of NBS for river landscapes contained a total of 650 NBS (Table S3). Most of the NBS represented measures to reduce sediment from soil erosion and surface run-off (27%), followed by measures for improving hydromorphological conditions of water bodies others than longitudinal continuity (22%) and measures to prevent or control the adverse impacts of invasive alien species and introduced diseases (11%) (Fig. 2). Measures to reduce sediment from soil erosion and surface run-off included NBS such as creating natural retention ponds and basins or creating buffer strips. Creating natural retention basins and ponds referred to increase the water storage capacity of the landscape by using natural, topographical depressions, excavated new depressions or constructed embankments to attenuate surface runoff from precipitation events and capture suspended materials. By creating buffer strips permanent natural vegetation cover is developed at the margin of the water body and the upper edge of embankments. The composition of the vegetation cover can vary and usually consists of a combination of different grasses, shrubs and/or trees, which slow down surface runoff and cause the deposition of suspended materials.

3.2. Local SDGs

All of the LDGs showed thematic overlaps with certain SDGs and hereinafter being referred to as local SDGs (Fig. 3). Most similarities with SDGs were identified for the group of LDGs aiming at the 'Introduction of coherent strategies for implementation of and compliance with legal obligations from European, country and federal state level' (#1, 16%). Introducing coherent strategies that consider requirements of legal obligations, such as the European Water Framework Directive, National Climate Adaptation Strategy, Federal Development Programmes ('Landesentwicklungsprogramme') of federal states and Regional Spatial Development Plans ('regionale Raumordnungspläne'), encompass topics that correspond with nine SDGs, for instance, 'Ensure availability and sustainable management of water and sanitation for all' (SDG 6) by protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes (SDG target 6.6) and 'Multi-stakeholder partnerships' (SDG 17) to balance ecological and socio-economic dimensions and enhance policy coherence for sustainable development (SDG target 17.14). Across all of the LDGs, the majority comprised topics that are in line with SDG 6 (40%). This is due to the great number of LDGs that addressed the protection and restoration of the Lahn river. However, not all SDGs were relevant in the Lahn river landscape. For the following four SDGs no thematic matches with LDGs could be found: 'Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' (SDG 4), 'Achieve gender equality and empower all women and girls' (SDG 5), 'Reduce inequality within and among countries' (SDG 10), and 'Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels' (SDG 16).

3.3. NBS to advance local SDGs

Potential contributions to attain multiple local SDGs were identified for all of the 38 NBS (Fig. 4). The top fifteen NBS, in Fig. 4, addressed the same number of local SDGs (71%) and can be considered as most influential in this analysis. These NBS comprise, for instance, *Renaturalising floodplains through land use changes, Revitalising historic floodplains, and Creating buffer strips*. All of the three aforementioned examples of NBS advance local SDGs including ecological goals such as to improve habitat networks (#14) and to improve structural elements of riverbanks, streams and drainage dynamics (#5) as well as socio-economic goals such as to protect against flooding (#9) and to enhance the attractiveness of the Lahn for residents, tourists and companies (#11). Despite the multifunctionality of the NBS, a solution could not be found for all local SDGs. This highlights that NBS are no panacea and need to be employed alongside other measures to achieve the largest possible number of local SDGs. Missing local SDGs refer either to social or economic issues that could not be addressed by a NBS or for which more evidence on the impact of the NBS is required. These local SDGs include: 'Strengthen environmental awareness' (#10), 'Co-design an integrated development concept for the Lahn river landscape' (#22), 'Establish a uniform, public, cross-border land-use cadaster for major characteristics of river landscape' (#30) and 'Manage river landscape in accordance with economic principles' (#12), and 'Develop ecologically and economically sustainable infrastructures' (#25).

3.4. Mapping of opportunity spaces for selected NBS

Results for the mapping of opportunity spaces to implement the NBS *Renaturalising floodplains through land use changes* showed that 3009 ha were available along the Lahn river. These opportunity spaces were areas without settlement structures and forest cover, characterised by intensive agricultural land use and a high risk of flood (MHW). See Fig. 5 for mapped opportunity spaces. For the NBS *Revitalising historic floodplains*, opportunity spaces with a size of 1730 ha were identified. These opportunity spaces represent historic floodplains that are not covered and surrounded by settlement structures and can potentially be reconnected to the active floodplains and ultimately the flood regime of the river. Additionally, small ($\leq$10 ha) and large historic floodplains ($>$11 ha) were distinguished, based on the assumption that the revitalisation and reconnection of larger historic floodplains is more efficient (Harms et al., 2018). Results showed that for 76% of the area of historic floodplains the majority were floodplains of greater than 11 ha. Mapping opportunity spaces for the NBS *Creating buffer strips*, showed that 1323 ha were potentially suitable for the conversion into buffer strips. The opportunity spaces include areas between the upper edge of the river embankment and up to 50 m inland along the Lahn river that were not covered by settlement structures or had already been stated as buffer strips.

3.5. Importance and validity of spatial indicators and opportunity spaces for NBS

Results of the extended peer review showed that all of the spatial indicators were valued as important to very important socio-ecological measures to map opportunity spaces for the three selected examples of NBS (Fig. 6). The feasibility of indicators for the application in practice varied between the NBS and individual indicators. For *Renaturalising floodplains through land use changes* all indicators were valued as easy to apply, yet for *Revitalising historic floodplains* and *Creating buffer strips* almost half of the indicators were valued as easy to medium. In particular, for *Creating buffer strips* peers mentioned that a hindrance is the difficulty to find data relating to the following indicators: 'Upper edge of

Table 2
Indicators and datasets used for the mapping of NBS opportunity spaces.

Indicators		Description of indicators (exclusion indicator = E, prioritization indicator = P)	Selected NBS			Source
			Revitalising historic floodplains	Renaturalising floodplains through land use changes	Creating buffer strips	
Recent river course		Flowing watercourse of the river Lahn. (P)	X	X	X	BKG, 2016
Location of active floodplain		Area directly connected to the river that is regularly inundated by flood water on a periodic basis. (P)	X	X		BMU and BfN, 2009
Location of historic floodplain		Former active floodplains that were disconnected from the flood regime of the river through dikes or embankments. (P)	X			BMU and BfN, 2009
Settlement structure	Settlement	Built-up and non built-up areas characterized by the settling of humans or which contribute to the settling. These areas, including a buffer of 50 m around them for hypothetical necessary flood protection facilities, were excluded for the identification of opportunity spaces. (E)	X	X	X	BKG, 2016
	Bridges, roads, highways	Routes or structures carrying routes which serve (pedestrian) traffic. These were excluded for the identification of opportunity spaces. (E)	X	X	X	BKG, 2016
	Underground pipelines, cables	Pipelines or cables for transporting water, gas, electrical energy or transmitting electrical signals. These were excluded for the identification of opportunity spaces. (E)	X	X	X	BKG, 2016
	Port facilities (ferry terminal, boat docks)	Fixed or floating facility for birthing of ships, including water areas of the docks and the areas on the land, which are covered by the shipyards, loading areas, storage buildings etc. These facilities were excluded for the identification of opportunity spaces. (E)	X	X	X	BKG, 2016
	Dikes (main and summer dikes)	Walls or banks of earth or stone built to protect against floods. These were excluded for the identification of opportunity spaces. (E)	X	X	X	BKG, 2016
Connected historic floodplain		Historic floodplains adjacent to the active floodplains that were not cut off by buildings, roads and other settlement structures. Reconnecting historic floodplains that were cut off by settlement structures were assumed to be expensive (Harms et al., 2018) and excluded. (P)	X			BMU and BfN, 2009
Size of historic floodplain		Spatial extent of historic floodplain. In this study it was assumed that reconnecting floodplains with smaller than 10 ha are too expensive (Harms et al., 2018) and consequently excluded. (P)	X			BMU and BfN, 2009
Permeability of recon-nected floodplain		Hydro-morphological conditions of historic floodplains enable water infiltration and backflow of water to the river. (E)	X			Missing
Property		Areas in possession of public or private bodies. It is assumed that the implementation of NBS on public ground is more likely than in private area (Bischoff et al., 2018). (P)	X	X	X	Missing
Mean high water (MHW)		MHW is the average of all the high-water heights observed over a period of several years (25 years) from Lahnstein to Gieβen. All areas inundated by MHW events were included for the identification of opportunity spaces. (P)		X		BFG, 2019
Agricultural use		Area for the cultivation of crops and animal husbandry. Areas of agricultural use were included for the identification of opportunity spaces. (P)		X		BKG, 2016
Forest area		Land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. Forest areas were discarded for the identification of opportunity spaces. (E)		X		BKG, 2016
Upper edge of embankment		Transition of the sloping embankment into the adjacent terrain characterised by a terrain slope change of >1.5° naturally created by the river or artificially by waterway development. The area between the upper edge of the embankment and up to 50 m inland was included in the analysis of the opportunity spaces. (E)			X	HLNUG, 2012, Wedel and Ott (2014)
Buffer strips already established		Areas of natural vegetation cover (grass, bushes or trees) along the river and adjacent to the upper edge of embankment which are fully available for water development. Silviculture, agriculture and recreational use are not allowed in buffer strips. Already existing buffer strips from 1 to 50 m (width from upper edge of embankment to inland) were			X	HLNUG, 2012, Wedel and Ott (2014)

(*continued on next page*)

Table 2 (*continued*)

Indicators	Description of indicators (exclusion indicator = E, prioritization indicator = P)	Selected NBS			Source
		Revitalising historic floodplains	Renaturalising floodplains through land use changes	Creating buffer strips	
	excluded for the identification of opportunity spaces. (P)				

embankment' and 'Buffer strips already established'. Furthermore, peers recommended the consideration of additional indicators, which mostly represented prioritization criteria (13 out of 17). For a detailed description of the indicators see Table S4. However, for almost half of these indicators the feasibility for the application in practice were valued as medium to complex. Major reasons for these values were the difficulty to organize available data from different data providers and across different federal states (e.g. data on 'Property'), missing data availability (e.g. 'Recent land use/cover'), as well as a high complexity in data generation (e.g. 'Stability of dikes after reconnecting historic floodplains', 'Digital orthophotos'). Additionally, it was found that supposedly existing data for indicators were in fact incomplete, for instance, the indicator: 'Location of cycle tracks', was recorded as mixture of walkways and cycle tracks or 'River bank reinforcement' included only sea walls, quay walls, culverts and weirs.

The visualisation of the spatial indicators and opportunity spaces for all three examples of NBS via touchscreens was intensively used by peers. However, none of the mapped indicators were revised or opportunity spaces spatially modified. Several key improvement opportunities for the valid mapping of indicators and opportunity spaces for the three examples of NBS were identified:

- Opportunity spaces should be divided into prioritized subspaces in order to increase their relevance for the implementation of NBS in practice. This includes the development of prioritization schemes for individual indicators, for instance, instead of using settlement structure in general as exclusion criterion, different subcategories of settlement structure (e.g. residential building area, parks and gardens) could be prioritized in accordance with their characteristics and associated level of impediment for spatial implementation of a NBS. Structural changes are more likely to be implemented in public parks than in residential building areas.
- Reduce the number of indicators to the absolute minimum required to avoid contestable exclusion of potentially suitable areas for the implementation of NBS and to minimize the complexity and capacities needed for mapping opportunity spaces.

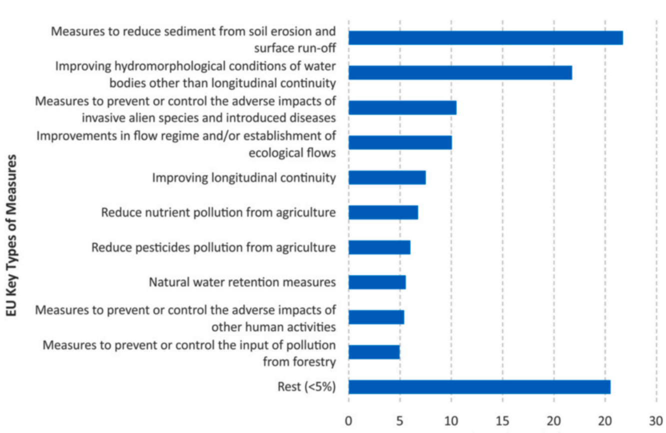

Fig. 2. The diagram shows the number of NBS contained in the catalogue according to the EU Key Type of Measures. Only the most frequent with ≥5% are shown. Others are summarized in the group 'Rest (<5%)'.

- Consider constantly updated datasets for the identification of opportunity spaces in order to account for changes in highly dynamic environments (e.g. buffer strips), illegal structures and uses (e.g. illegal settlement structures), as well as approved spatial interventions that are still in the process of implementation (e.g. creation of cycle tracks).
- Distinguish the indicator's level of feasibility for application in practice in accordance with the administrative borders to accurately consider the substantial differences in data availability across federal states.
- Advance the identification of opportunity spaces in the steep-sided v-shape valleys of the mountainous terrain of the southern Lahn river course, because NBS might be recognized more easily in those river stretches, thus potentially enhancing public understanding and support.

Findings of the workshop evaluation showed that the presented method is highly relevant for landscape planning processes in the Lila project (Fig. 7). The majority of the participants of the extended peer review agreed that they have gained knowledge about potential options for action for the prospective development of the Lahn region and they felt better prepared to contribute to discussions and decision-making processes for a sustainable development of the Lahn region.

4. Discussion

Six years after the introduction of the United Nations 2030 Agenda for Sustainable Development still confusion exists on how to localise global SDGs and which role NBS can play to advance the achievement of SDGs. In this paper a pragmatic method is suggested that: i) contributes

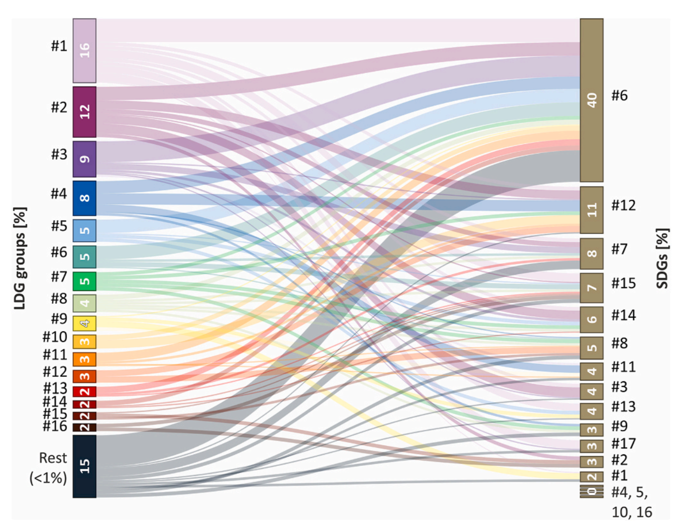

Fig. 3. The alluvial diagram shows local SDGs in the Lahn river landscape by visualising thematic links (connecting ribbons) between LDGs and SDGs (see Table 1 for the legend of code numbers and colour code). The colour codes and size of the connecting ribbons represent the group of LDGs and the number of interlinkages (%) between LDGs and SDGs. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

to advance the understanding of NBS and their potential to address multiple development goals, ii) localises SDGs and iii) identifies opportunity spaces for NBS that address multiple local SDGs. These contributions were discussed critically in the following sections regarding implications of the choices made in each working step of the presented method and insights on the results gained.

4.1. Advance the understanding of NBS and their potential to address multiple development goals

In the first working step of the presented method a NBS catalogue was developed that makes actions explicit that can be considered as NBS and also provides a baseline to develop a common vocabulary towards more operational rigor of the NBS concept (Nesshöver et al., 2017). While broad definitions for NBS exist from policy (European Commission, 2015b) as well as different disciplines of science (Eggermont et al., 2015; Nesshöver et al., 2017; Frantzeskaki et al., 2017; Welden et al., 2021) and standards on what constitutes NBS are under development (International Union for Conservation of Nature, 2020), practitioner friendly overviews that demonstrate which specific actions are considered as NBS are missing. NBS in the catalogue were additionally structured based on official classification systems already applied for documentation and reporting in practice, among others the EU Key Types of Measures (European Commission, 2015a). The alignment of NBS with standardized classification systems provides the advantage of using widely agreed-upon terms and semantics administered by a well-respected neutral organization to make them more accessible and relevant for practitioners as well as increase confidence in the use of NBS. However, many standardized classification systems are tailored to specific use contexts and lacking a more integrative perspective (Polasky et al., 2015). One drawback of using the EU Key Types of Measures was that the classification system focused on the ecological perspective of measures to improve river landscapes, while neglecting other

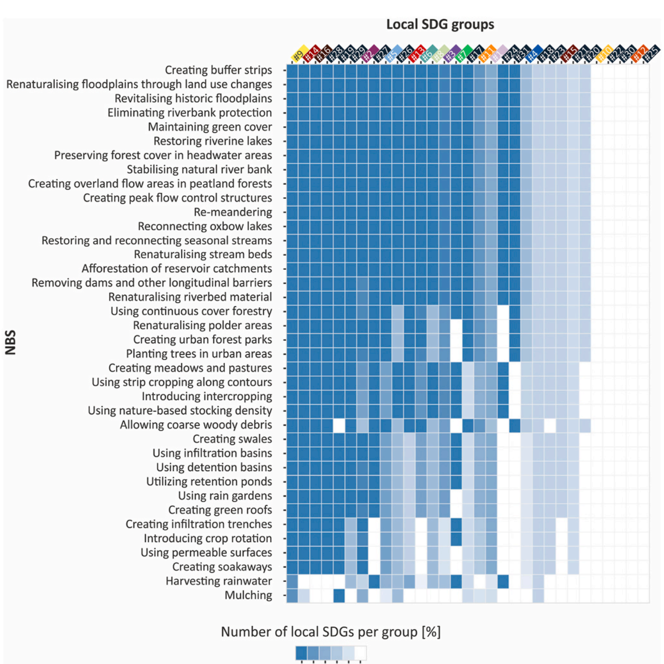

Fig. 4. The heatmap illustrates the potential contribution of NBS to attain local SDGs by visualising the number of local SDGs that can be addressed by NBS. The local SDGs are grouped according to thematic similarities (see Table 1 for the legend of code numbers and colour code). The darker the bluish colour, the greater the number of local SDGs addressed in one group by the NBS (percentage value). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

dimensions such as social and human health aspects. There is a substantial merit in conducting further systematic reviews in how additional standardized classification systems from official documentation and reporting in practice contribute to reduce conceptual confusions on NBS, support harmonisation of terminologies and reveal the multi-functionality of NBS from different socio-ecological perspectives to realise its full potential.

In the working step three, examples of NBS were identified that contribute to attain multiple development goals simultaneously. By taking the multifunctionality of NBS into account, synergetic effects could be revealed that may contribute to mediate contestations between different stakeholder groups. For instance, in this study was shown that *Revitalising historic floodplains* could not only contribute to ecological development goals (e.g. Improve structural elements of riverbanks, streams and drainage dynamics, Improve the habitat network), but also provide socio-economic co-benefits (e.g. Protect against flooding, Enhance attractiveness of Lahn for residents, tourists and companies). A shared understanding of such NBS co-benefits is essential to better exploit synergetic solutions and avoid isolated interventions that may result in incoherent policies, adverse impacts on policies in other areas, policy impact being delayed in unforeseen ways; and impaired prioritization and sequencing actions, causing less efficient or effective resource use (Otto-Portner et al., 2021; Alcamo et al., 2020; Scholz et al., 2012).

4.2. Localisation of SDGs

One way to localise SDGs is to explore how SDGs mesh with local development goals and subsequently identify NBS that address coherent, local SDGs. The process to identify local SDGs in the presented method (second working step) benefited greatly from the groundwork done by the LiLa project, in which LDGs were surveyed (IKU, 2018b; IKU, 2018c; IKU, 2018a; Best et al., 2019). A considerable amount of money and resources could be saved because the findings of the two-years survey could be directly used as input for the content analysis and identification of local SDGs. The content analysis is seen as a powerful technique to identify local SDGs by finding the right equivalent of a term or topic across LDGs and SDGs (Stemler, 2015). A major challenge however, was the translation and reduction of different terminologies and concepts used in the definition of different development goals into fewer content categories (local SDGs), which implied the risk of knowledge loss, poor scoping and increased controversy (Pereira and Funtowicz, 2005). To ensure the reliability of the content analysis, two of the authors of this article checked independently the development goals for similar topics. The list of similar development goals prepared by the two authors were then compared and disagreements resolved, either through discussion or the involvement of the third author of this article. Similar techniques that are recommended to address reliability challenges in content analysis are available in Weber (1990), Stemler (2001), and Krippendorff and Bock (2009). Also, an extended peer review could be used to cross-validate the findings from the content-analysis by interviewing peers about the extent to which the inferences made on the basis of the development goals are well-founded. Although, the content analysis and local SDGs were presented in the extended peer review of this article, an explicit evaluation of the local SDGs was beyond the scope of this article.

The identification of NBS that address local SDGs was based on a semi-quantitative assignment of potential effects of NBS according to Natural Water Retention Measures (2015) for a shortlist of 38 examples of NBS. While such semi-quantitative evaluations present a good starting point to generate a broad yet relevant representation of interlinkages between NBS and their potential to contribute to local SDGs, more scientific evidence is needed of how NBS actually contribute to attaining ecological and socio-economic outcomes in different context conditions. In particular, more integrated and site-specific appraisals of causal relationships between NBS attributes, ecosystem services and societal challenges are needed, also in comparison with outcome assessments for

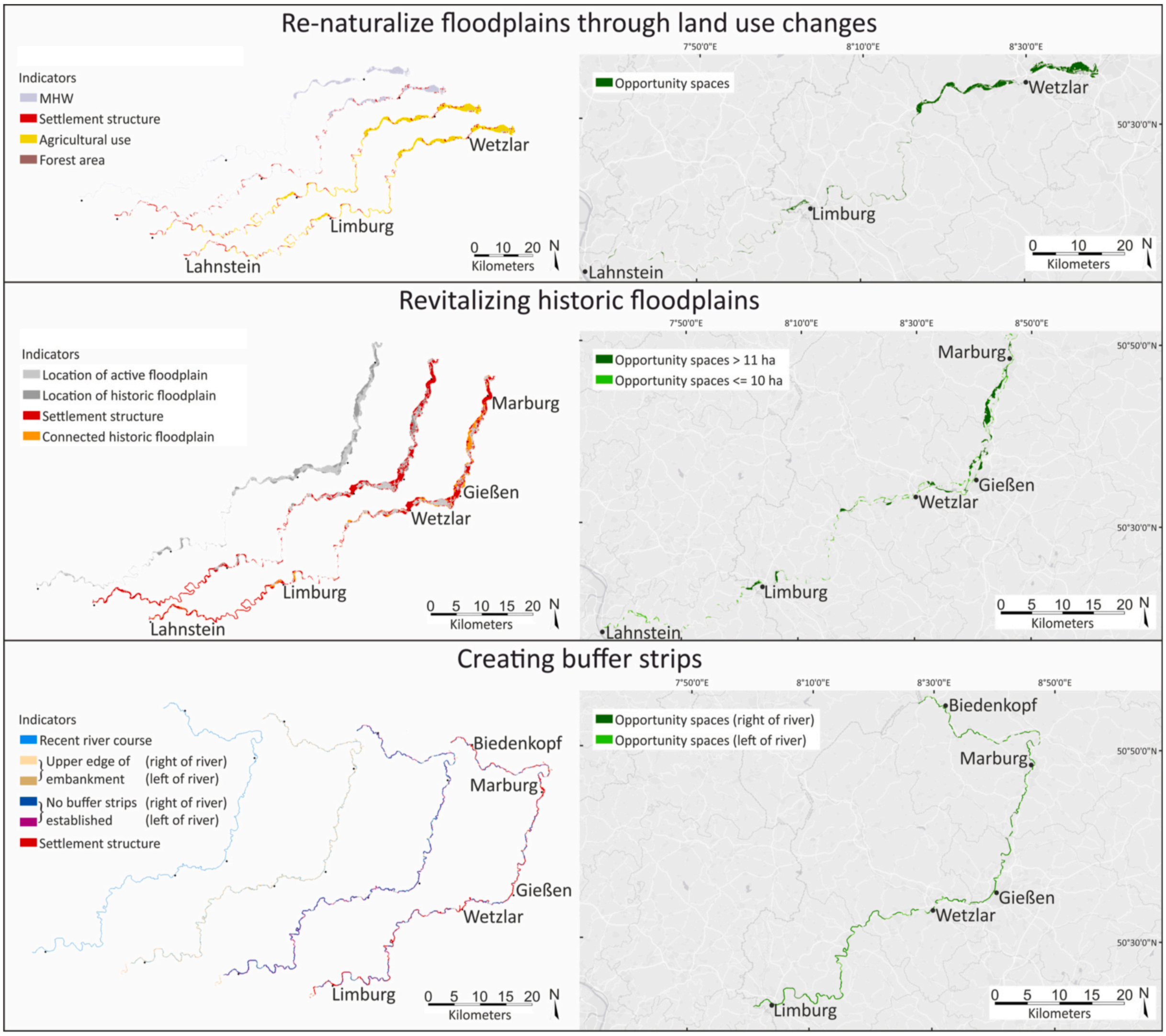

Fig. 5. The maps illustrate the location of the spatial attributes as measured by selected indicators (left) and the resulting opportunity spaces (right) for each of the three examples of NBS (*Renaturalising floodplains through land use changes*, *Revitalising historic floodplains*, and *Creating buffer strips*).

conventional, technical alternatives (Chausson et al., 2020; Babí Almenar et al., 2021; European Commission, 2021a).

Localising SDGs and implementing NBS identified in this article will require stronger emphasizing socio-institutional feasibility issues such as power relations, equity and justice, informal decision-making processes, and the opportunities presented by existing legislative and regulatory processes that shape the context of decision-making (Sekulova et al., 2021; Ershad Sarabi et al., 2019; Frantzeskaki et al., 2020). Feasibility assessments should also include more in-depth analyses of multiple dimensions of benefits and costs of policy options with or without NBS (Randrup et al., 2020). This will require not only an understanding of the economic costs of interventions, but also the potential social and eco-centric benefits (Kopsieker et al., 2021; Pineda-Pinto et al., 2021). Further research is required on enablers and barriers of NBS implementation in terms of collaboration and governance (Martin et al., 2021; Malekpour et al., 2021).

4.3. *Identification of opportunity spaces for NBS that address multiple local SDGs*

Opportunity spaces for NBS were identified based on spatial key indicators representing major local conditions (fourth working step). However, internationally agreed, standardized key indicators to map NBS are so far non-existent and selecting indicators requires balancing simplification and oversimplification of socio-ecological conditions. The complexity of indicators used to map NBS are manifold and vary broadly (LAWA–Bund/Länder-Arbeitsgemeinschaft Wasser, 2016; Guerrero et al., 2018). While simplification is needed to enable the usage and application in practice, oversimplification is unsatisfactory for the mapping of opportunity spaces of NBS and can mislead decision-making (Barbier et al., 2008). Findings of this study emphasized to use an approach guided by the Occam's Razor (Baker, 2016), meaning that not more indicators than the minimum needed should be included to avoid contestable exclusion of potentially suitable areas for the implementation of NBS and to keep the complexity and effort for mapping opportunity spaces low. In this context, opportunity spaces should be understood as coarse search corridors that provide a basis for further specified analysis in which local experts identify and consider circumstances that are not apparent from the available geo-data in order to exclude or take account of additional areas. Further steps to enhance the prioritization of selected areas are provided by Harms et al. (2018).

Results of the spatial evaluation based on the extended peer review suggested that the validity of the location of the three selected examples of NBS was sufficient to support landscape planning and decision-making processes in the development of the Lahn region's integrative development plan. Additional indicators that may even improve the

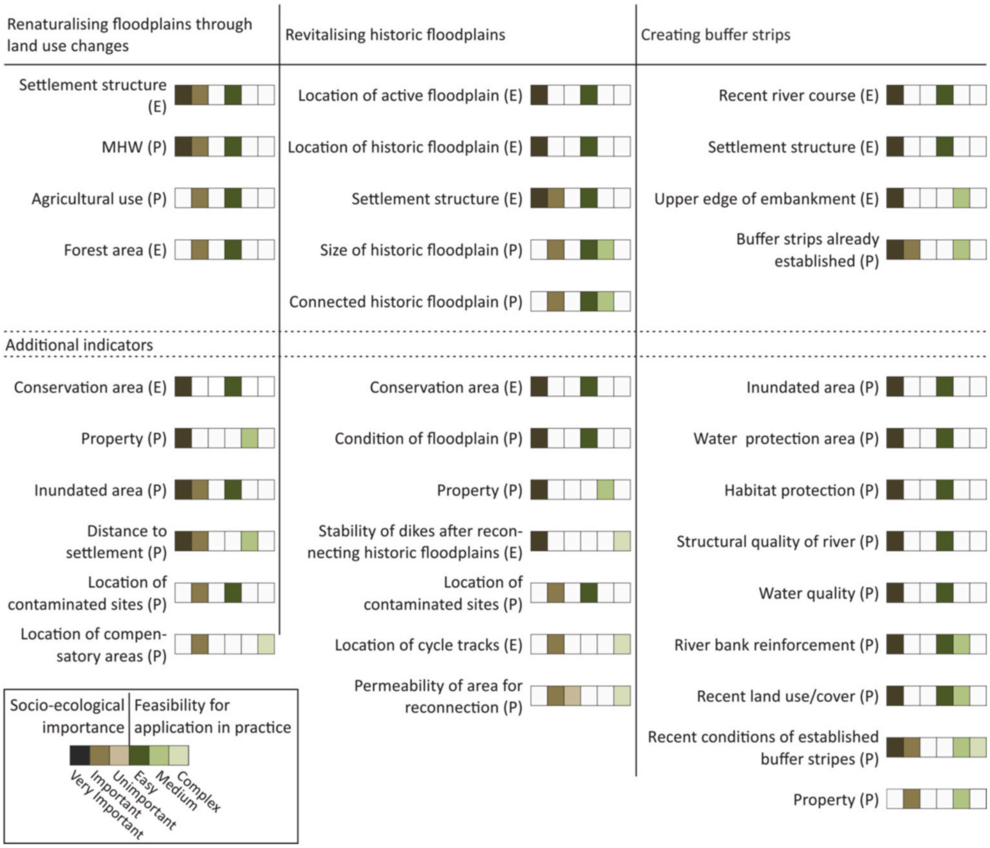

Fig. 6. The figure shows the evaluation results of spatial indicators used to map opportunity spaces for the three examples of NBS based on the extended peer review. Each indicator was evaluated according to the socio-ecological importance to map a NBS (1 very important, 2 important, 3 not important) and the feasibility for the application in practice for landscape planning (1 easy, 2 medium, 3 complex). Also, additional indicators recommended by peers for the mapping of each example of NBS were listed. The capitalised letter in parentheses indicates whether the indicator is an exclusion (E) or prioritization criterion (P).

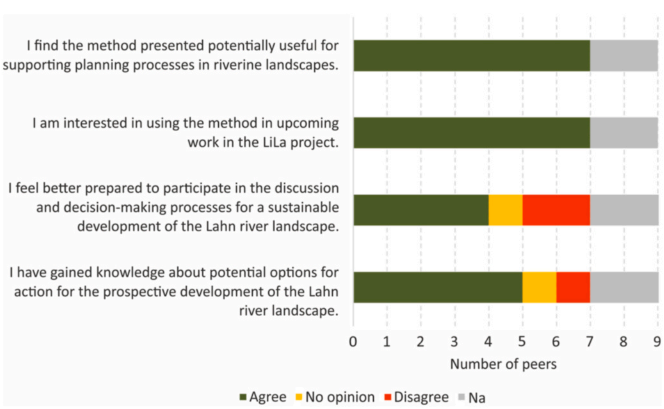

Fig. 7. Evaluation results of the method's relevance for the application in the Lila project according to the nine surveyed non-academic actors and practitioners of the extended peer review.

mapping of NBS opportunity spaces recommended by peers could not be considered due to not accessible or missing geo-datasets. The access to data was hampered by varying access rights and costs of different data providers across administrative borders. While efforts are continuing to establish spatial data infrastructures that facilitate the exploration of geo-datasets and harmonize geo-data for the seamlessly use in cross boarder applications (GDI-DE, 2021; European Commission, 2021b) and discussions on open data are ongoing (German Federal Government, 2019; Perez et al., 2019), findings of the study showed additional tools are required that enable time and resource saving data generation of more up-to-date spatial information. In particular, tools are needed to consider changes in highly dynamic environments (e.g. buffer strips), illegal structures and uses (e.g. illegal settlement structures), and approved spatial interventions that are in the process of implementation (e.g. creation of cycle tracks). Promising tools such as remote sensing, citizen science, digital twins and the Internet of Things may help to fill the data gap (Tomsett and Leyland, 2019; Galle et al., 2019; Moshref-zadeh et al., 2020).

4.4. *Outlook: Further advancements and transferability*

Findings of the study showed that the presented approach was easy to apply in practice and relevant for landscape planning processes in riverine landscapes such as the Lahn region. However, the method's level of feasibility for application in practice is tied to the application case of the Lahn river landscape. Nevertheless, the conceptual workflow steps of the presented approach provide a roadmap for the localisation of SDGs and mapping of NBS opportunity spaces in different contexts. The approach's workflow steps can be further advanced towards more efficient performance and ease of use for the application in other case studies by utilizing knowledge management technologies and automation processes such as an ontology linked into a workflow management system (Madin et al., 2008; Ludäscher et al., 2009). By doing so the following advancements could be realized:

i) An extendable, formal model (ontology) would be set up that defines concepts and relationships within the NBS domain (e.g. different NBS examples) in a language which can be interpreted by both humans and computer applications (Gruber, 1993). Formally defining the variations in meaning or ambiguity in NBS interpretations, their specific ecological impacts and contributions to societal challenges provides a basis to discuss differences and agree upon rigorously defined and scientific sound terms and relationships. Therefore, the NBS ontology could contribute to define a common vocabulary for people who need to share information facilitating closer collaborations. Updating and curating the NBS ontology over long-term by institutions such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services task force on knowledge and data (IPBES, 2019) could contribute to set the bar for a large segment of the community, effectively developing a universal standard.

ii) Data mapping would be realized, i.e. indicators and datasets from distributed information sources could be captured and centralized through the NBS ontology (Madin et al., 2007). This process would provide a foundation for a greater level of automation of data exploration and integration, thus improving data visibility and accessibility (Madin et al., 2008). In other words, indicators and data could be found more easily to map NBS in different application cases.

iii) A greater level of automation could be established for the execution of presented workflow steps. Operated by a workflow management system, a NBS ontology that is linked with data for NBS mapping could be combined with computational analysis and visualising tools (Ludäscher et al., 2009; GitHub, 2021). Therefore, working steps and their execution could be streamlined with less human interventions, for instance, working steps such as data queries, dataset merging, summarization of contextual information of NBS evidence from different databases and geo-datasets as well as the mapping of opportunity spaces.

Utilizing ontologies aligned with open standards such as the Semantic Web initiative (Berners-Lee et al., 2001), which is a programme to standardize languages and technologies for improving information exchange over the Internet, could take full advantage of the growing repositories of NBS and geo-data on the Internet to optimize the knowledge base for the selection of NBS and mapping of opportunity spaces as well as to facilitate the transferability of the method for the use in other case studies worldwide.

5. Conclusions

A key challenge on the road to realizing the United Nations' ambitious vision of achieving SDGs by 2030 is to designate locally attuned goal interpretations, suitable actions and implementation solutions. This paper has forwarded a pragmatic method that harnesses NBS to address SDG challenges in sustainable ways and provides spatial decision support to identify and map suitable and synergistic actions. Applying and evaluating the method in the Lahn river landscape case study revealed five key advantages: First, the method enhanced the tangibility of the NBS concept for practitioners and stakeholders by specifying local NBS actions. Second, the multifunctionality of NBS and potential impacts on ecosystem services were revealed helping to infer causal links with socio-ecological benefits and local as well as global development goals (LDGs and SDGs). Third, the method clarified how to downscale global SDGs into local NBS actions. Fourth, the mapping of NBS opportunity spaces supported landscape planners and decision makers to identify potentially suitable areas for the implementation. Fifth, the extended peer review by non-academic actors and practitioners enabled the integration of local knowledge, thereby enhancing the quality and relevance of the presented method and identifying remaining knowledge gaps for future research.

Further steps towards actual realization, upscaling and mainstreaming of NBS will require designing suitable financing and governance models and linking NBS planning with processes of formal land and resource use decision-making.

Participants of the extended peer review interpreted the presented method and its results as of high relevance and usefulness for the support of decision-making process for the future development of the Lahn region. We therefore recommend applying the approach in other case study regions as a way to advance NBS, to foster transformative change towards attaining local SDGs, and to yield positive impacts for both people and nature.

Author statement

Schmidt, Stefan: Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualisation, Supervision, Project administration, **Guerrero, Paulina:** Resources, Writing – review & editing, **Albert Christian:** Resources, Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2022.114696.

References

Acharya, P., Gupta, A.K., Dhyani, S., Karki, M., 2020. New pathways for NbS to realise and achieve SDGs and post 2015 targets: transformative approaches in resilience building. In: Dhyani, S., Gupta, A.K., Karki, M. (Eds.), Nature-based Solutions for Resilient Ecosystems and Societies. Springer Singapore, Singapore, pp. 435–455.

Albert, C., Brillinger, M., Guerrero, P., et al., 2020. Planning nature-based solutions: principles, steps, and insights. Ambio. https://doi.org/10.1007/s13280-020-01365-1.

Albert, C., Schröter, B., Haase, D., et al., 2019. Addressing societal challenges through nature-based solutions: how can landscape planning and governance research contribute? Landsc. Urban Plann. 182, 12–21. https://doi.org/10.1016/j.landurbplan.2018.10.003.

Alcamo, J., Thompson, J., Alexander, A., et al., 2020. Analysing interactions among the sustainable development goals: findings and emerging issues from local and global studies. Sustain. Sci. 15, 1561–1572. https://doi.org/10.1007/s11625-020-00875-x.

Babí Almenar, J., Elliot, T., Rugani, B., et al., 2021. Nexus between nature-based solutions, ecosystem services and urban challenges. Land Use Pol. 100, 104898. https://doi.org/10.1016/j.landusepol.2020.104898.

Baker, A., 2016. Stanford encyclopedia of philosophy. Simplicity. In: California: the Metaphysics Research Lab. Stanford University.

Barbier, E.B., Koch, E.W., Silliman, B.R., et al., 2008. Coastal ecosystem-based management with nonlinear ecological functions and values. Science 319, 321–323. https://doi.org/10.1126/science.1150349.

Bebbington, J., Unerman, J., 2018. Achieving the united Nations sustainable development goals. Acc. Audit. Acc. J. 31, 2–24. https://doi.org/10.1108/AAAJ-05-2017-2929.

Berners-Lee, T., Hendler, J., Lassila, O., 2001. The Semantic Web - a new form of web content that is meaningful to computers will unleash a revolution of new possibilities. Sci. Am. 284, 34–43. https://doi.org/10.1038/scientificamerican0501-34.

Best, R, Geisler, K, Grommelt, HJ, et al., 2019. Erlebnisreiche Lebensader Lahn. Anregungen zum Lahnkonzept LiLa-Living Lahn 2025NABU Landesverband Hessen; BUND; HGON. Online: https://hessen.nabu.de/imperia/md/content/hessen/gewaesser/zielartenkonzept_f_r_lila_livinglahn-konzept.pdf. Accessed: November/2020.

BFG – Bundesanstalt für Gewässerkunde, 2019. FLYS – Flusshydrologischer Webdienst. Online. April/2020. https://www.bafg.de/DE/08_Ref/M2/03_Fliessgewmod/01_FLYS/flys_node.html#doc177526bodyText5.

Bischoff, S., Michalk, B., Mußbach, J., Mautner, O., 2018. Gewässerökologische Potentialanalyse für die Aller und ihre Aue zwischen Celle und ihrer Mündung in die Weser. NABU Institut für Fluss- und Auenökologie, Rathenow.

BKG – Bundesamt für Kartographie und Geodäsie, 2016. Digital Basic Landscape Model (AAA Modelling) Basic-DLM (AAA). Status of the Documentation: 01.04. Online.

July/2021 2016. https://gdz.bkg.bund.de/index.php/default/digitales-basis-landschaftsmodell-ebenen-basis-dlm-ebenen.html?__SID=U.
BMU, BfN – Bundesministerium für Umwelt, 2009. Naturschutz und Reaktorsicherheit, Bundesamt für Naturschutz. Auenzustandsbericht Flussauen in Deutschland.
Chausson, A., Turner, B., Seddon, D., et al., 2020. Mapping the effectiveness of nature-based solutions for climate change adaptation. Global Change Biol. 26, 6134–6155. https://doi.org/10.1111/gcb.15310.
Cohen-Shacham, E., Janzen, C., Maginnis, S., Walters, G., 2016. Nature-based Solutions to Address Global Societal Challenges. Gland. Online. https://doi.org/10.2305/IUCN.CH.2016.13.en. November/2020. https://portals.iucn.org/library/sites/library/files/documents/2016-036.pdf.
Colquhoun, H., Levac, D., O'Brien, K., et al., 2014. Scoping reviews: time for clarity in definition, methods, and reporting. J. Clin. Epidemiol. 67, 1291–1294. https://doi.org/10.1016/j.jclinepi.2014.03.013.
Convention on Biological Diversity, 2000. X/2.Strategic Plan for Biodiversity 2011-2020.
de Jesús Arce-Mojica, T., Nehren, U., Sudmeier-Rieux, K., Miranda, P.J., Anhuf, D., 2019. Nature-based solutions (NbS) for reducing the risk of shallow landslides: where do we stand? Int. J. Disaster Risk Reduc. 41 https://doi.org/10.1016/j.ijdrr.2019.101293.
Division of Sustainable Development Goals, 2019. Stakeholders E-Consultation on the Sustainable Development Goals (SDGs) under Review at the 2019 High Level Political Forum on Sustainable Development (HLPF). Online. November/2020. https://sustainabledevelopment.un.org/content/documents/23258FINAL_Report_EConsultations_SDGs_under_review_2019_HLPF_June_2019.pdf.
Dudley, N., Ali, N., Kettunen, M., MacKinnon, K., 2017. Editorial Essay: Protected Areas and the Sustainable Development Goals. https://doi.org/10.2305/IUCN.CH.2017.PARKS-23-2ND.en. Parks 23. 10-2.
Easterly, W., 2015. The trouble with the sustainable development goals. Curr. Hist. 114, 322–324. https://doi.org/10.1525/curh.2015.114.775.322.
Eggermont, H., Balian, E., Azevedo, M., et al., 2015. Nature-based solutions: new influence for environmental management and research in Europe. Gaia Okol. Perspektiven Natur-, Geistes- Wirtschaftswiss. 24, 243–248. https://doi.org/10.14512/gaia.24.4.9.
Ershad Sarabi, S., Han, Q., Romme, A.G.L., de Vries, B., Wendling, L., 2019. Key enablers of and barriers to the uptake and implementation of nature-based solutions in urban settings: a review. Ressoruces 8. https://doi.org/10.3390/resources803012.
ESRI, 2010. Building models that let users interact with maps. Online: https://www.esri.com/news/arcwatch/0310/tip.html. Accessed: November/2020.
European Commission, 2015a. Commission Staff Working Document. Report on the Progress in Implementation of the Water Framework Directive Programmes of Measures. Accompanying the Document. Communication from the Commission to the European Parliament and the Council. The Water Framework Directive and the Floods Directive: Actions towards the 'good Status' of EU Water and to Reduce Flood Risks. Online. November/2020. https://ec.europa.eu/environment/water/water-framework/pdf/4th_report/CSWD%20Report%20on%20WFD%20PoMs.pdf.
European Commission, 2015b. Towards an EU Research and Innovation Policy Agenda for Nature-Based Solutions & Re-naturing Cities. Final Report of the Horizon 2020 Expert Group on Nature-Based Solutions and Re-naturing Cities. Luxembourg. Online. https://doi.org/10.2777/765301. März/2021. https://op.europa.eu/en/publication-detail/-/publication/fb117980-d5aa-46df-8edc-af367cddc202.
European Commission, 2021a. Evaluating the Impact of Nature-Based Solutions: a Handbook for Practitioners. Publications Office. https://doi.org/10.2777/244577.
European Commission, 2021b. INSPIRE Knowledge Base. Infrastructure for Spatial Information in Europe. Online. December/2021. https://inspire.ec.europa.eu/.
Faivre, N., Fritz, M., Freitas, T., de Boissezon, B., Vandewoestijne, S., 2017. Nature-Based Solutions in the EU: innovating with nature to address social, economic and environmental challenges. Environ. Res. 159, 509–518. https://doi.org/10.1016/j.envres.2017.08.032.
Frantzeskaki, N., Borgström, S., Gorissen, L., Egermann, M., Ehnert, F., 2017. Nature-based solutions accelerating urban sustainability transitions in cities: lessons from Dresden, Genk and Stockholm cities. In: Kabisch, N., Korn, H., Stadler, J., Bonn, A. (Eds.), Nature-based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice. Springer International Publishing, Cham, pp. 65–88.
Frantzeskaki, N., Vandergert, P., Connop, S., et al., 2020. Examining the policy needs for implementing nature-based solutions in cities: findings from city-wide transdisciplinary experiences in Glasgow (UK), Genk (Belgium) and Poznań (Poland). Land Use Pol. 96, 104688. https://doi.org/10.1016/j.landusepol.2020.104688].
Funtowicz, S.O., Ravetz, J.R., 2015. Peer review and quality control. In: Wright, J.D. (Ed.), International Encyclopedia of the Social & Behavioral Sciences, second ed. Elsevier, Oxford, pp. 680–684.
Galle, N.J., Nitoslawski, S.A., Pilla, F., 2019. The Internet of Nature: How Taking Nature Online Can Shape Urban Ecosystems, vol. 6, pp. 279–287. https://doi.org/10.1177/2053019619877103.
GDI-DE, 2021. Decisions of the Steering Committee Meetings. Online. Federal Agency for Cartography and Geodesy, Frankfurt am Main. December/2021. https://www.gdi-de.org/en/SDI/steering%20commitee/decisions.
German Federal Government, 2019. Erster Bericht der Bundesregierung über die Fortschritte bei der Bereitstellung von Daten (1. Open-Data-Fortschrittsbericht). Drucksache 19/14140. Berlin. Online. June/2021. https://www.bmi.bund.de/SharedDocs/downloads/DE/veroeffentlichungen/themen/moderne-verwaltung/erster-fortschrittsbericht-open-data.pdf;jsessionid=FBFAFBA302B9D04590E8D761F1269CFB.2_cid295?_blob=publicationFile&v=2.
GitHub, 2021. Existing Workflow Systems. Computational Data Analysis Workflow Systems. An Incomplete List. Online. December/2021. https://s.apache.org/existing-workflow-systems.
Global Taskforce of Local and Regional Governments, UNDP, UN-Habitat, 2016. Roadmap for Localizing the SDGs: Implementation and Monitoring at Subnational Level. Barcelona. Online. November/2020. https://www.uclg.org/sites/default/files/roadmap_for_localizing_the_sdgs_0.pdf.
Global Taskforce of Local and Regional Governments UNHSP, United Nations Development Programme, 2020. Local 2030 Localizing the SDGs. Online. November/2020. https://www.local2030.org/.
Griscom, B.W., Adams, J., Ellis, P.W., et al., 2017. Natural climate solutions. Proc. Natl. Acad. Sci. U. S. A 114, 11645–11650. https://doi.org/10.1073/pnas.1710465114.
Gruber, T.R., 1993. A translation approach to portable ontology specifications. Knowl. Acquis. 5, 199–220. https://doi.org/10.1006/knac.1993.1008.
Guerrero, P., Haase, D., Albert, C., 2018. Locating Spatial Opportunities for Nature-Based Solutions: A River Landscape Application, vol. 10, p. 1869.
Harms, O., Dister, E.R., Gerstner, L., et al., 2018. Potenziale zur naturnahen Auenentwicklung – Bundesweiter Überblick und methodische Empfehlungen für die Herleitung von Entwicklungszielen. BfN-Skripten 489. Online. Bonn - Bad Godesberg: Bundesamt für Natutschutz. https://doi.org/10.19217/skr489. November/2020. https://www.bfn.de/fileadmin/BfN/service/Dokumente/skripten/Skript489.pdf.
Henze, J., Schröter, B., Albert, C., 2018. Knowing me, knowing you—capturing different knowledge systems for river landscape planning and governance. Water 10, 934–957. https://doi.org/10.3390/w10070934.
HLNUG – Hessisches Landesamt für Naturschutz, 2012. Umwelt und Geologie. Gewässerstrukturgüte. Online. July/2021. http://wrrl.hessen.de/mapapps/resources/apps/wrrl/index.html?lang=de.
IKU, 2018a. Bürgerforum Zukunft Lahn: Bürgerreport mit Zielepapier. Dortmund. Online. July/2021. https://www.lila-livinglahn.de/fileadmin/files/lila/public/Actions/A1/Grundlagenermittlung/Interessenerhebung/Interessenerhebung/Themen-AGs_und_Zielepapiere/Bericht_Buergerforum_mit_Zielepapier.pdf.
IKU, 2018b. Dialogprozess zur Erarbeitung des Lahnkonzepts. Bericht Themen-AGs 17. Oktober 2017 – 22. Februar 2018. Online. November/2020. https://www.lila-livinglahn.de/fileadmin/files/lila/public/Bericht_Themen_AGs_inklusive_Zielepapiere.pdf.
IKU, 2018c. Dokumentation Abschlussveranstaltung Phase 1 Interessenerhebung. Dortmund. Online. https://www.lila-livinglahn.de/fileadmin/files/lila/public/Dokumentation_zur_Abschlussveranstaltung_der_Interessenerhebung.pdf. Accessed: December/2021.
International Union for Conservation of Nature, 2020. IUCN Global Standard for Nature-Based Solutions. A User-Friendly Framework for the Verification, Design and Scaling up of NBS. Online. Gland: IUCN. https://doi.org/10.2305/IUCN.CH.2020.08.en. November/2020. https://portals.iucn.org/library/sites/library/files/documents/2020-020-En.pdf.
IPBES, 1990. Decision IPBES-7/1: Rolling work programme of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services up to 2030. Online: https://www.ipbes.net/sites/default/files/decision_ipbes-7_1_en.pdf. Accessed: February/2022.
Kopnina, H., 2016. The victims of unsustainability: a challenge to sustainable development goals. Int. J. Sustain. Dev. World Ecol. 23, 113–121. https://doi.org/10.1080/13504509.2015.1111269.
Kopsieker, L., Gerritsen, E., Stainforth, T., et al., 2021. Nature-based Solutions and Their Socio-Economic Benefits for Europe's Recovery: Enhancing the Uptake of Nature-Based Solutions across EU Policies. Policy Briefing. Online. June/2021. https://ieep.eu/uploads/articles/attachments/0b733817-b56a-4872-afc9-43ccff2ad6ba/Nature-based%20solutions%20and%20their%20socio-economic%20benefits%20for%20Europe%E2%80%99s%20recovery%20(IEEP%202021)%20WEB.pdf?v=63781383755.
Krippendorff, K., Bock, M.A., 2009. The Content Analysis Reader. SAGE Publications.
LAWA – Bund/Länder-Arbeitsgemeinschaft Wasser, 2016. LAWA Verfahrensempfehlung „Typspezifischer Flächenbedarf für die Entwicklung von Fließgewässern“. LFP Projekt O 4.13. Bund/Länder-Arbeitsgemeinschaft Wasser. Hilden, Aachen. Online. June/2021. http://www.laenderfinanzierungsprogramm.de/static/LFP/Dateien/LAWA/AO/o-4-13-2014-anwenderhandbuch.zip.
LAWA, 2020. LAWA-BLANO Maßnahmenkatalog (WRRL, HWRMRL, MSRL). LAWA-arbeitsprogramm Flussgebietsbewirtschaftung LAWA. Online. In: German Working Group on Water Issues of the Federal States and the Federal Government. November/2020. https://www.lawa.de/documents/lawa-blano-massnahmenkatalog_2_1595486344.pdf.
Le Blanc, D., 2015. Towards integration at last? The sustainable development goals as a network of targets. Online. In: DESA Working Paper No. 141ST/ESA/2015/DWP/141. Affairs UN Department of Economic & Social Affairs, New York. https://www.un.org/esa/desa/papers/2015/wp141_2015.pdf. (Accessed November 2020).
Lee, D.J., Dinar, A., 1995. Review of integrated approaches to river basin planning, development, and management. Online. In: Policy Research Working Paper Series. The World Bank. November/2020. https://ideas.repec.org/p/wbk/wbrwps/1446.html.
Living Lahn, 2014. LIFE Integrated Projects 2014. Stage 2 – Full Proposal. Technical Application Forms. Part B – Technical Summary and Overall Context of the Project. Online. November/2020. https://www.lila-livinglahn.de/fileadmin/files/lila/public/Doku/LIFE_I_Summary_Website.pdf.
Ludäscher, B., Altintas, I., Bowers, S., et al., 2009. Scientific process automation and workflow management. In: Shoshani, A., Rotem, D. (Eds.), Scientific Data Management. Chapman & Hall. (Computational Science Series.

Madin, J., Bowers, S., Schildhauer, M., Krivov, S., Pennington, D., Villa, F., 2007. An ontology for describing and synthesizing ecological observation data. Ecol. Inf. 2, 279–296. https://doi.org/10.1016/j.ecoinf.2007.05.004.
Madin, J.S., Bowers, S., Schildhauer, M.P., Jones, M.B., 2008. Advancing ecological research with ontologies. Trends Ecol. Evol. 23, 159–168. https://doi.org/10.1016/j.tree.2007.11.007.
Malekpour, S., Tawfik, S., Chesterfield, C., 2021. Designing collaborative governance for nature-based solutions. Urban For. Urban Green. 62, 127177. https://doi.org/10.1016/j.ufug.2021.127177.
Martin, J.G.C., Scolobig, A., Linnerooth-Bayer, J., Liu, W., Balsiger, J., 2021. Catalyzing Innovation: Governance Enablers of Nature-Based Solutions, vol. 13, 1971.
Moshrefzadeh, M., Machl, T., Gackstetter, D., Donaubauer, A., Kolbe, T.H., 2020. Towards a distributed digital twin of the agricultural landscape. J. Dig. Lands. Architect. 173–185. https://doi.org/10.14627/537690019.
Moss, T., Monstadt, J., 2008. Restoring Floodplains in Europe: Policy Contexts and Project Experiences. IWA Publishing. https://doi.org/10.2166/9781780401966.
Natural Water Retention Measures, 2014. Selecting, Designing and Implementing Natural Water Retention Measures in Europe: Capturing the Multiple Benefits of Nature-Based Solutions. Online. November/2020. http://nwrm.eu/id-card/files/assets/basic-html/index.html#1.
Natural Water Retention Measures, 2015. Synthesis Document N°2. Biophysical Impacts and Effectiveness of Natural Water Retention Measures, and Their Contribution to Policy Objectives. Service Contract n°07.0330/2013/659147/SER/ENV.C1. Online. European Commission. November/2020. http://nwrm.eu/sites/default/files/sd2_final_version.pdf.
Nesshöver, C., Assmuth, T., Irvine, K.N., et al., 2017. The science, policy and practice of nature-based solutions: an interdisciplinary perspective. Sci. Total Environ. 579, 1215–1227. https://doi.org/10.1016/j.scitotenv.2016.11.106.
Norton, A., Stuart, E., 2014. How Far Down the Road? Comments on the Secretary-General's Synthesis Report on Post-2015. London. Online. https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9385.pdf. (Accessed November 2020).
Otto-Portner, H., Scholes, B., Agard, J., et al., 2021. Scientific Outcome of the IPBES-IPCC Co-sponsored Workshop on Biodiversity and Climate Change (Version 4). Online. IPBES, Bonn, Germany. https://doi.org/10.5281/zenodo.5031995. https://zenodo.org/record/5031995#.YNn56OdCRjE.
Pereira, A., Funtowicz, S., 2005. Quality assurance by extended peer review: tools to inform debates, dialogues and deliberations. TATuP - Zeitschrift für Technikfolgenabschätzung Theorie und Praxis 14, 74–79. https://doi.org/10.14512/tatup.14.2.74.
Perez, J.A.R., Emilsson, C., Ubaldi, B., 2019. Open, Useful and Re-useable Data (OURdata) Index: 2019. OECD Public Governance Policy Papers No. 1. Online. OECD Publishing, Paris. December/2021. https://www.oecd.org/governance/digital-government/ourdata-index-policy-paper-2020.pdf.
Pineda-Pinto, M., Frantzeskaki, N., Nygaard, C.A., 2021. The potential of nature-based solutions to deliver ecologically just cities: lessons for research and urban planning from a systematic literature review. Ambio. https://doi.org/10.1007/s13280-021-01553-7.
Polasky, S., Tallis, H., Reyers, B., 2015. Setting the bar: standards for ecosystem services. Proc. Natl. Acad. Sci. U. S. A 112, 7356–7361. https://doi.org/10.1073/pnas.1406490112.
Pradhan, P., Costa, L., Rybski, D., Lucht, W., Kropp, J.P., 2017. A Systematic Study of Sustainable Development Goal (SDG) Interactions, vol. 5, pp. 1169–1179. https://doi.org/10.1002/2017EF000632.
Randrup, T., Buijs, A., Konijnendijk van den Bosch, C., Wild, T., 2020. Moving beyond the nature-based solutions discourse: introducing nature-based thinking. Urban Ecosyst. 23 https://doi.org/10.1007/s11252-020-00964-w.
Raymond, C.M., Frantzeskaki, N., Kabisch, N., et al., 2017. A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environ. Sci. Pol. 77, 15–24. https://doi.org/10.1016/j.envsci.2017.07.008.
Refsgaard, J.C., van der Sluijs, J.P., Højberg, A.L., Vanrolleghem, P.A., 2007. Uncertainty in the environmental modelling process – a framework and guidance. Environ. Model. Software 22, 1543–1556. https://doi.org/10.1016/j.envsoft.2007.02.004.
Rosato, P.F., Caputo, A., Valente, D., Pizzi, S., 2021. 2030 Agenda and sustainable business models in tourism: a bibliometric analysis. Ecol. Indicat. 121, 106978. https://doi.org/10.1016/j.ecolind.2020.106978.
Scharlemann, J.P.W., Brock, R.C., Balfour, N., et al., 2020. Towards understanding interactions between Sustainable Development Goals: the role of environment–human linkages. Sustain. Sci. 15, 1573–1584. https://doi.org/10.1007/s11625-020-00799-6.
Schindler, S., O'Neill, F.H., Biró, M., et al., 2016. Multifunctional floodplain management and biodiversity effects: a knowledge synthesis for six European countries. Biodivers. Conserv. 25, 1349–1382. https://doi.org/10.1007/s10531-016-1129-3.
Scholz, M., Mehl, D., Schulz-Zunkel, C., et al., 2012. Ökosystemfunktionen von Flussauen Analyse und Bewertung von Hochwasserretention, Nährstoffrückhalt, Kohlenstoffvorrat, Treibhausgasemissionen und Habitatfunktion; Ergebnisse des F+E-Vorhabens (FKZ 3508 850 100).
Scott, A., Lucci, P., Berliner, T., 2015. Mind the Gap? A Comparison of International and National Targets for the SDG Agenda. London. Online. November/2020. https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9663.pdf.
Seddon, N., Daniels, E., Davis, R., et al., 2020. Global recognition of the importance of nature-based solutions to the impacts of climate change. Glob. Sustain. 3 https://doi.org/10.1017/sus.2020.8.
Seddon, N., Sengupta, S., Garcia Espinosa, M., Hauler, I., Herr, D., Rizvi, A.R., 2019. Nature-based Solutions in Nationally Determined Contributions: Synthesis and Recommendations for Enhancing Climate Ambition and Action by 2020. Online. IUCN, Oxford. November/2020. https://portals.iucn.org/library/sites/library/files/documents/2019-030-En.pdf.
Sekulova, F., Anguelovski, I., Kiss, B., et al., 2021. The governance of nature-based solutions in the city at the intersection of justice and equity. Cities 112, 103136. https://doi.org/10.1016/j.cities.2021.103136.
Stemler, S., 2001. Published. An overview of content analysis. Practical Assess. Res. Eval. 1–6 https://doi.org/10.7275/z6fm-2e34.
Stemler, S.E., 2015. Content analysis. Emerg. Trend. Soc. Behav. Sci. 7, 1–14. https://doi.org/10.1002/9781118900772.etrds0053.
Sutherland, W.J., Gardner, T., Bogich, T.L., et al., 2014. Solution scanning as a key policy tool: identifying management interventions to help maintain and enhance regulating ecosystem services. Ecol. Soc. 19 https://doi.org/10.5751/ES-06082-190203.
Swain, R.B., 2018. A critical analysis of the sustainable development goals. In: Leal Filho, W. (Ed.), Handbook of Sustainability Science and Research. Springer International Publishing, Cham, pp. 341–355.
Teusch, M., Maltzan, J., 2019. Lahnkonzept Status-Analyse. Teilbericht „Ökologie und Naturschutz" Wasserstraßen- und Schifffahrtsamt Koblenz, Hessisches Ministerium für Umwelt, Klimaschutz, Landwirtschaft und Verbraucherschutz. Online November/2020. https://www.lila-livinglahn.de/fileadmin/files/lila/public/Actions/A1/Grundlagenermittlung/Grundlagen/Teilbericht_Oekologie_und_Naturschutz/Teilbericht_Oekologie_und_Naturschutz.pdf.
Tockner, K., Stanford, J.A., 2002. Riverine flood plains: present state and future trends. Environ. Conserv. 29, 308–330. https://doi.org/10.1017/S037689290200022X.
Tomsett, C., Leyland, J., 2019. Remote Sensing of River Corridors: A Review of Current Trends and Future Directions, vol. 35, pp. 779–803. https://doi.org/10.1002/rra.3479.
Tosun, J., Leininger, J., 2017. Governing the Interlinkages between the Sustainable Development Goals: Approaches to Attain Policy Integration, vol. 1, pp. 2056–6646. https://doi.org/10.1002/gch2.201700036.
Tricco, A.C., Zarin, W., Ghassemi, M., et al., 2018. Same family, different species: methodological conduct and quality varies according to purpose for five types of knowledge synthesis. J. Clin. Epidemiol. 96, 133–142. https://doi.org/10.1016/j.jclinepi.2017.10.014.
United Cities and Local Governments, 2014. How to localize targets and indicators of the post-2015 Agenda. Online. In: UCLA Inputs for the Global Taskforce Working Paper. November/2020. https://www.local2030.org/library/view/70.
United Cities and Local Governments, 2019. Local and Regional Governments' Report to the 2018 HLPF—3rd Report: towards the Localization of the SDGs. Barcelona. Online. November/2021. https://www.uclg.org/sites/default/files/towards_the_localization_of_the_sdgs_0.pdf.
United Nations, 2000. United Nations Millennium declaration. General assembly resolution 55/2 of 8 september 2000. Online May/2021. https://www.ohchr.org/EN/ProfessionalInterest/Pages/Millennium.aspx.
United Nations General Assembly, 2015. A/RES/70/1 - Transforming Our World: the 2030 Agenda for Sustainable Development. Online. May/2021. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf.
United Nations World Water Assessment Programme, 2018. The United Nations World Water Development Report 2018: Nature-Based Solutions for Water. Online. UNESCO, Paris. November/2021. https://unesdoc.unesco.org/ark:/48223/pf0000261424_eng.
Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., et al., 2010. Global threats to human water security and river biodiversity. Nature 467, 555–561. https://doi.org/10.1038/nature09440.
Wedel, J., Ott, T., 2014. Neukartierung der Gewässerstruktur wasserrahmenrichtlinienrelevanter Fließgewässer in Hessen – ein erfahrungsbericht. 29-36, 978-3-89026-376-2. In: HLUG – Hessisches Landesamt für Umwelt und Geologie. 2015. Jahresbericht 2014 des Hessischen Landesamtes für Umwelt und Geologie. Hessisches Landesamt für Umwelt und Geologie, Wiesbaden. July/2021. https://www.hlnug.de/ueber-uns/jahresberichte/jahresbericht-2014.html.
Weber, R., 1990. Basic Content Analysis. https://doi.org/10.4135/9781412983488. Thousand Oaks, California.
Welden, E.A., Chausson, A., Melanidis, M.S., 2021. Leveraging nature-based solutions for transformation: reconnecting people and nature. People Nat. 1–12. https://doi.org/10.1002/pan3.10212.