A Framework for Evaluating Performance of Large-Scale Nature-Based Solutions to Reduce Hydro-Meteorological Risks and Enhance Co-benefits

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Chapter 33
A Framework for Evaluating Performance of Large-Scale Nature-Based Solutions to Reduce Hydro-Meteorological Risks and Enhance Co-benefits

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Abstract Over recent decades, hydro-meteorological disasters appear to be becoming more intense and frequent. Nature-Based Solutions (NBS) have been introduced to address hydro-meteorological risks as they offer the possibility of working closely with nature. This provides solutions to adapt to future changes in climate and society, as well as to achieve multiple benefits to services and functions of ecosystems. However, the performance and efficiency of NBS for hydro-meteorological risk reduction are still highly uncertain. Scientists and decision-makers require holistic perspectives and frameworks to help understand, evaluate and design NBS in such a way that can minimize social and economic losses, reduce environmental impacts and increase resilience to hydro-meteorological events. Therefore, methods or frameworks that can be used to evaluate NBS performance are necessary. In this work, a framework for evaluating large-scale NBS for hydro-meteorological risks is presented. The evaluation framework is separated into three main stages; identification of Indicators, before implementation (ex-ante) evaluation and after implementation (ex-post) evaluation. Developing a framework will be useful in assisting and supporting communities that wish to implement NBS for hydro-meteorological risk reduction, as well as communities that have implemented NBS and wish to assess their effectiveness. The work presented here is part of the EC-funded HORIZON 2020 RECONECT project (Regenerating Ecosystems with Nature-based solutions for hydro-meteorological risk rEduCTion).

Keywords Impact assessment · Monitoring · Stakeholders involvement · Hazards · NBS

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33.1 Introduction

Every year disasters caused by natural hazards affect millions of people around the world. The incidence and frequency of these hazards have increased during the past few decades [1–3]. This situation can be viewed as a result of our disconnected developments underpinning broader global environmental and sustainability problems [4], as well as our fragmented ways of dealing with natural disasters [5].

Nature-Based Solutions (NBS) are inherently flexible and will naturally adapt to changing conditions [6]. In addition to helping minimizing risks, NBS measures provide several other benefits. NBS have been used in numerous cases especially in runoff reduction or flood risk reduction in urban areas. Only implementing small NBS at urban scales may not be sufficient for large events as the frequency and intensity of futures events may increase due to future changes. Large scale NBS (i.e., as applied in rural areas, river basins, and/or at the regional scale) may provide a more significant impact in different management scenarios [7].

NBS require holistic perspectives and frameworks to help scientists and decision-makers to understand their complexity and to evaluate and design them in such a way that can minimize social and economic losses, reduce environmental impacts and increase resilience to hydro-meteorological events. The uncertainty of effectiveness of NBS for hydro-meteorological risk reduction are still highly. Therefore, the methods or frameworks that can be used to assess the performance is necessary.

For implemented NBS, the monitoring and evaluation process can be significantly enhanced to help to determine whether NBS are actually working, will NBS adapt to expected climate change or can NBS perform better. However, there is still a lack of methods that can be used to help in answering the above questions.

The present work presents a framework for evaluating large-scale NBS for hydro-meteorological risks. The evaluation framework consists of three main stages; identification of Indicators, before implementation (ex-ante) evaluation and after implementation (ex-post) evaluation. The work is developed within the EC-funded HORIZON 2020 RECONECT project (Regenerating Ecosystems with Nature-based solutions for hydro-meteorological risk rEduCTion) [8].

33.2 Background

33.2.1 Selection and Assessment of Measures to Reduce Hydro-Meteorological Risks

In order to select and assess measures to reduce hydro-meteorological risks, an exhaustive list of potential measures for achieving risk reduction is needed. This could be obtained by analyzing the past practices and literature. Often, decision-makers require a careful balance between different objectives, criteria, scientific findings and multi-faceted interests from different stakeholders [9]. The objectives of NBS depends on the types of problems and the local characteristics of the area [10, 11].

Various methods are available to carry out the selection and evaluation processes, which have been reviewed [7]. The most common methods are Multi-criteria Analysis (MCA) and Cost Benefit Analysis (CBA).

In the preliminary stage, it may not be feasible or necessary to evaluate the measures in detail (i.e., using modelling) as there are so many measures available and it is time consuming to assess the performance for all of them. Therefore, such an analysis would be best carried out through a screening process from various perspectives [10, 12, 13].

After the list of measures is shortened, more detailed analysis could be introduced by considering cost effectiveness and feasibility of the measures. In this analysis, combination of measures should be considered to meet objectives. The appropriate combination of measures will optimize the project's objectives as well as its social and environmental benefits [14]. Moreover, this process may help to identify synergy and trade-offs of NBS [15].

The selection of best options is a challenge for decision makers, thus it is important to involve stakeholders from the beginning of the project.

33.2.2 Monitoring and Evaluation

Monitoring and evaluation should be planned as an essential part of the project planning process. Monitoring of basin condition before, during and after the implementation of the measures is essential to check its performance and sustainability. The monitoring and evaluation is a continuous process which can lead to new insights into NBS functioning and active learning, even from failures, which can help to improve future NBS implementation [16].

The indicators are usually used to monitor and assess performance of implemented measures. To do so, it is important to carefully select and agree on the appropriate indicators [9, 12, 14] and they should cover all aspects and objectives of the project, including integrated environmental performance, health and well-being benefits, civil participation and transferability of NBS actions [11, 17, 18]. The indicators can be used to show how results will be measured and provide an overview of change over time.

Different indicators require different monitoring data collection methods, which can be quantitative and qualitative (e.g., measurements, field observation, questionnaires and satellite data), and different monitoring frequencies (e.g., short-term, intermediate and long-term).

Evaluation is the process of comparing data between a baseline scenario and after implementation. Baselines are often based on the data before implementing measures and a threshold target, but could also be based on the impact of similar events in the past. Method for evaluating the effectiveness of NBS should take the changing dynamics of system in both spatial and temporal scales into account [11, 18, 19].

33.3 Define the Evaluation Framework

The evaluation framework can be used to guide the process of evaluation. Developing a framework will be useful in assisting and supporting communities that wish to implement NBS for hydro-meteorological risk reduction, as well as communities that have implemented NBS and wish to assess their effectiveness.

To develop the evaluation framework, a systematic review of existing literature was performed. The literature is based on the Scopus database which focuses on publication from 2007 onwards. The literature was selected based on relevant terminologies related to NBS such as Low Impact Developments (LIDs), Best Management Practices (BMPs), Water Sensitive Urban Design (WSUD), Sustainable Urban Drainage Systems (SuDS), Green Infrastructure (GI), Blue-Green Infrastructure (BGI), Ecosystem-based Adaptation (EbA) and Ecosystem-based Disaster Risk Reduction (Eco-DRR) [7].

There are various factors and processes in the evaluation of NBS that have been proposed in the literature. The framework will be developed on these scientific principles and studies by answering the questions below:

(1) What are the factors that are involved in the performance process?

In the first question, the potential factors that are used to evaluate the performance of NBS are considered. Some examples include; indicators, local constraints, stakeholders, costs, benefits, and climate changes. The reason that we need to consider these factors is that different projects may have different requirements and interests.

(2) What is the potential use of this framework?

Typically we need to consider multiple aspects which depend on the objectives of the project, as each project may view the performance of NBS differently. For example; some projects may only want to estimate the feasibility of potential future measures while others may want to assess the performance of currently implemented NBS and how can they be improved. According to APFM [20] there is a time dimension of evaluation, which is before and after the action. Evaluation before the action is ex-ante evaluation while evaluation after action is ex-post evaluation.

(3) What methods are appropriate in order to evaluate NBS?

As a consequence of the above questions, the evaluation framework is separated into two processes, which are ex-ante evaluation and ex-post evaluation. These evaluations will provide answers to communities and decision makers as to what are the processes and methods that they should follow. The methods that may be used to evaluate NBS will be explained in Sect. 33.4.

33.4 A Framework for Evaluating Performance of Large-Scale Nature-Based Solutions to Reduce Hydro-Meteorological Risks and Enhance Co-benefits

The objective of this framework is to help in the decision making process and performance evaluation of large-scale NBS to reduce hydro-meteorological risk and enhance their co-benefits. The framework is divided into 3 stages (Fig. 33.1). The first stage is the identification of indicators for both quantitative and qualitative benefits of NBS. This includes identifying the main benefits and co-benefits of NBS. The next stage is the planning for potential NBS (Ex-ante evaluation). Ex-ante assessment defines the potential measures that are quantified as effective by applying the best scientific knowledge and technical means. The last stage is the evaluation of

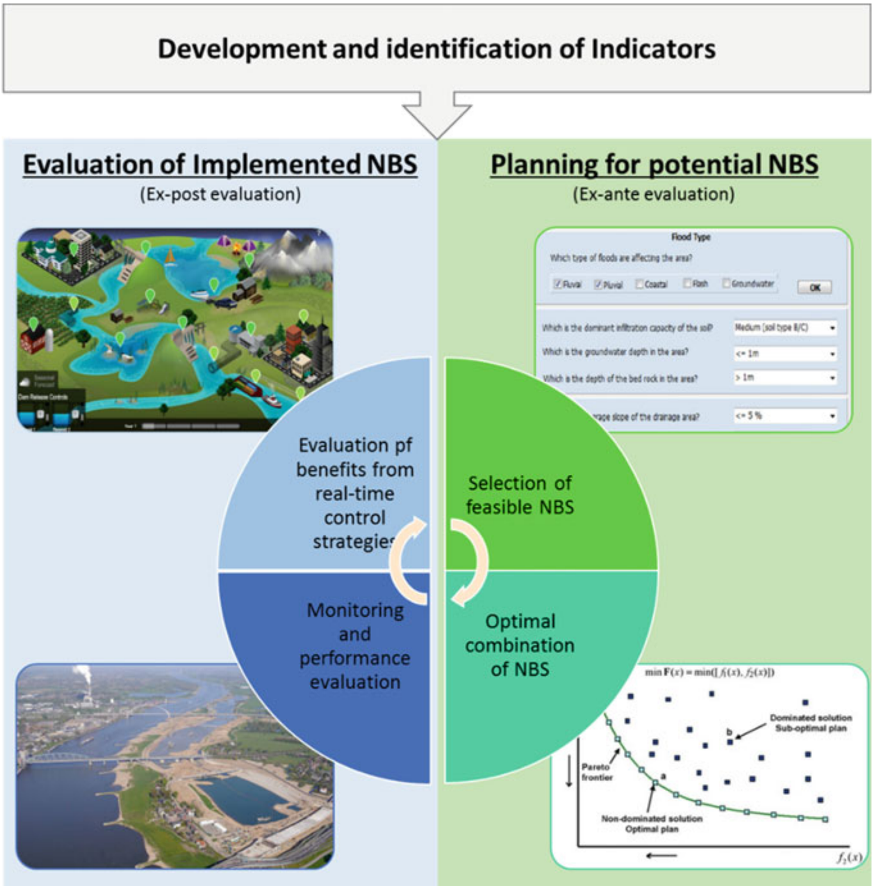

Fig. 33.1 An overall framework for evaluating performance of large-scale nature-based solutions to reduce hydro-meteorological risks and enhance co-benefits

implemented NBS (Ex-post evaluation). Ex-post evaluation can be done in different ways such as comparing a baseline with monitored data, interviewing stakeholders or collecting data the field. Ex-post assessment often introduces operational strategies in order to achieve the maximum benefits.

33.4.1 Identification of Indicators

Since there is no universally agreed set of indicators and variables that can be used for every NBS case study, it is necessary to develop a tool that supports the selection of specific indicators and variables, reflecting a variety of local contexts and situations. The idea is to narrow down the number of indicators to ensure that they are useful and effective in their provision of information. In the RECONECT project, we have developed an indicator framework and tool to help decision makers to select relevant indicators for their case studies. The indicator tool is in the excel format. The framework applied for the development of indicators and variables is illustrated in Fig. 33.2.

The framework starts from an NBS 'Solution' and proceeds through 'Challenges', 'Goals', 'Sub-Goals' in order to come up with the list of 'Indicators' and 'Variables':

1. **Solution** refers to a particular site where a solution has already been implemented or it will be implemented.
2. **Challenge** refers to RECONECT challenge areas: Water, Nature and People.
3. **Goal** represents a theme/topic within the challenge area (these could be water quantity, water quality, habitat structure, biodiversity, socio-economic and human well-being).
4. **Sub-Goals** are subthemes within 'Goals' which will be assessed through indicators.
5. **Indicators,** which are derived from variables, are the first, most basic, *metrics or aspects* which can be used to measure, describe or assess the change and state of sub-goals over a period of time.
6. **Variables,** which are the most basic component of indicators, are data which can be used to monitor/measure and assess change in the state of indicators.

A framework for evaluating performance is carried out in relation to three categories of challenges i.e., WATER, NATURE and PEOPLE. The WATER challenge addresses questions related to hydro-meteorological risks. This includes watershed runoff and river, coastal, and groundwater processes. Also, some interactions with urban areas will be addressed as well. The NATURE challenge addresses questions

Fig. 33.2 Framework for the development of indicators and variables

related to habitat structure and the biodiversity of flora and fauna. Implementation of large-scale NBS has the potential to improve habitat conditions, species territorial expansion and colonization of new areas. The PEOPLE challenge addresses questions concerning social and economic benefits, with implications for human health and well-being, and resilience to impacts from hydro-meteorological events.

33.4.2 Ex-ante Evaluation

Ex-ante evaluation aims to identify and estimate the potential values of NBS before the implementation of a project. This evaluation includes the local knowledge, scientific knowledge, and technical means. The ex-ante evaluation framework consist of two phases; Selection of feasible NBS and optimisation evaluation.

33.4.2.1 Selection of Feasible NBS

The phase 1 of this evaluation includes preliminary selection (screening) of NBS, Multi-criteria analysis framework, and preliminary spatial analysis (Fig. 33.3). The RECONECT database was developed to provide an extensive list of measures for hydro-meteorological risk reduction.

The first step in this phase is the preliminary selection to define the potential measures that are applicable or feasible to the case study based on the local characteristics. The selection is based on six filters, i.e., measure types, hazard types, affected areas, potential areas, potential location, project types and land use types [13].

The second step is a multi-criteria analysis framework (MCA) to select and rank potential measures [13]. This framework allows the stakeholders to give their preferences on the benefits of NBS and select measures that are more suitable or applicable to implement. MCA employ three methodologies, namely weighting, scoring and ranking. The criteria used in this MCA framework is based on the RECONECT indicator framework, which are referred to as goals and sub-goals. The criteria is weighted according to their relative importance and used to score options.

The final step is the preliminary spatial analysis to define the potential location of NBS in selected site and upscaling possibilities. The main objectives in this step are to ensure that selected measures are suitable for the area and to find the appropriate location for measures in order to achieve the most benefit and least impact to society. In this assessment, an in-depth spatial analysis is developed for stakeholders to have a better understanding of the current topology of the area and to show the preliminary possible location of measures. The analysis is based on land use information, physical conditions, topographical condition, and hydrological conditions of the site. GIS application is used to generate a spatial suitability map for NBS placement. With the use of GIS, it is possible to portray the location.

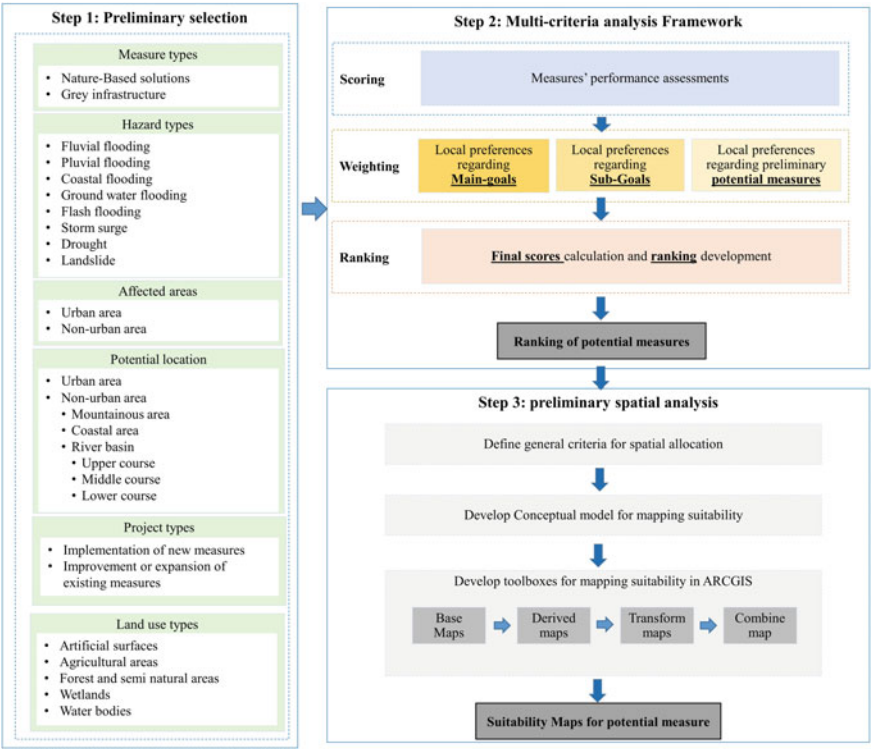

Fig. 33.3 Selection of feasible NBS process (adapted from [13])

33.4.2.2 Optimal Combination of NBS

For complex systems with a large number of scenarios and parameters, simple trial-and-error methods may not be sufficient. Optimisation could be an alternative approach to handle the intensive computations in the trial-test process and to combine multi-objective criteria. Therefore, the second phase is optimal combination of NBS to define the best combination and trade-off of NBS. Figure 33.4 shows the optimization assessment process that will be applied in this research.

The optimisation starts with the definition of promising scenarios. Scenarios include different NBS measures, future changes (i.e. climate change and land use change), and different return periods of events. A numerical (hydrodynamic) model with the optimization tool will be combined to compare the effectiveness of feasible measures. The results of simulations are then used to carry out cost–benefit analysis. The methods for cost–benefit analysis will be based on whole Life-cycle costs (LCC) and Return On Investment (ROI).

The optimization criteria are defined as objective functions to compare the different outputs with specific targets. The targets in this research are to

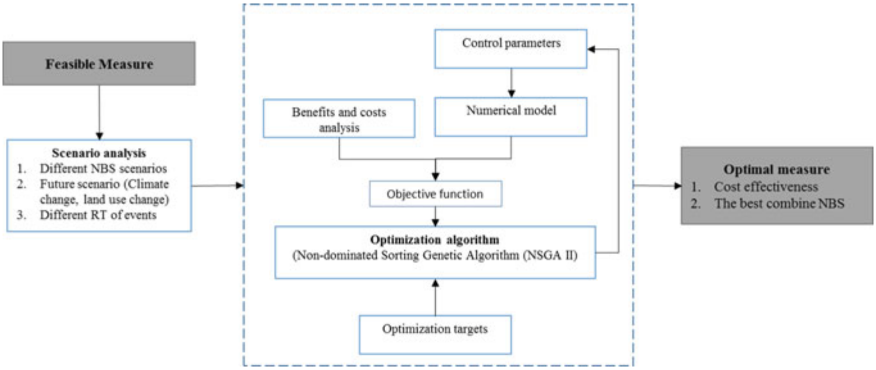

Fig. 33.4 Optimization assessment process

minimize investment costs and maximise benefits. The costs include construction/implementation, maintenance, and operation. The benefits consist of two groups, which are the reduction of damage to the environment, economic and infrastructure and co-benefits such as energy saving, agriculture profit and profit from tourism. Both benefits are quantified and evaluated using a monetary valuation approach to have the same unit in the objective function. Based on the calculated objective functions the optimization algorithm selects new sets of solutions (i.e. the size, location, and potential combinations of NBS) to be evaluated.

The optimisation tool is based on the non-dominated sorting genetic algorithm II (NSGA-II) to identify the Pareto solution. NSGA-II is a multialgorithm, genetically adaptive multiobjective (AMALGM) method using the multilevel spatial optimization (MLSOP) framework [21]. NSGA-II remains one of the best multiobjective evolutionary algorithms (MOEAs) (even with limited parameter tuning) and generally outperforms the other MOEAs concerning the number of solutions contributing to the best-known non-dominated set of each problem [22]. Moreover, NSGA II has been successfully applied in the water management field. The output of this optimisation is the size and type of NBS that can be implemented in the basin.

33.4.3 Ex-post Evaluation

Ex-post evaluation aims to address information of implemented interventions. The ex-post evaluation consists of 2 different phases, which are monitoring and performance evaluation and evaluation of benefits from real-time control strategies. Monitoring and performance evaluation aims to evaluate the effectiveness of NBS for hydro-meteorological risk reduction (main-target) and co-benefits. Evaluation of benefits from real-time control strategies aims to improve their effectiveness by introducing real-time control strategies.

33.4.3.1 Monitoring and Performance Evaluation

The performance evaluation generates insights on what works, what does not work and why. One of the goals of this research is to demonstrate and further upscale large-scale NBS. To support this goal, it is important to develop monitoring and evaluation procedures that can be applied to different types of NBS and their local contexts and settings. In order to assess the performance of solutions, indicator selection, baseline estimation and solution monitoring and evaluation are all important. A co-monitoring and co-evaluation framework is being developed for Demonstrators A and B in the RECONECT project. In this framework the performance evaluation consists of risk reduction and co-benefits (impact on community and nature). Co-benefits are divided into five sub-goals; Water quality, biodiversity, habitat structure, socio-economic development and human well-being.

This part of the research is divided into four steps. First of all, indicators are selected to reflect short and medium-term changes which will show the likelihood of a solution's success in the long run. The reason for this is that the selection of indicators is a core component of monitoring and evaluation.

The next step is to monitor and assess the state of the system (e.g. the general conditions in the NBS area), i.e., baseline monitoring. The baselines could be the targets of the project or the situation before implementation. These baselines will be compared against measured data.

After constructing the baselines, monitoring and collecting data of implemented NBS to achieve the project's goals/sub-goals is required. Monitoring can help increase understanding and identify future needs. Monitoring data will be supported within the RECONECT project. Monitoring parameters and collecting data will be carefully selected based on the indicators. These parameters will cover all aspects of WATER, NATURE and PEOPLE. Data collection depends on indicators. In order to monitor NBS effectively, monitoring should be straight-forward and relatively inexpensive to measure.

In terms of evaluating the effectiveness of NBS, indicator assessment methodologies are needed. The indicator assessment methodologies can be used to identify (for a particular selected indicator), which datasets and data processing procedures may be used to assess the indicator.

33.4.3.2 Evaluation of Benefits from Real-Time Control Strategies

The study will develop an innovative method for real-time operation and control of existing NBS systems, to improve their effectiveness for both single and multiple NBS from passive to active control. The innovation method is called "SMART NBS". SMART NBS consists of four main components: monitoring, data processing, modelling (hydrodynamic and optimisation) and control. There are some NBS measures that SMART NBS can be applied to such as rainwater harvesting, detention ponds, retention ponds, and secondary channels.

For SMART NBS, real-time monitoring is needed as an input for the hydrodynamic model to simulate the optimal control strategies. Examples of real-time data are rainfall, water level, and discharge. Before data can be used, we need to calibrate and validate the accuracy of data.

33.5 Conclusions

The proposed framework aims to evaluate performance of large-scale NBS for reducing hydro-meteorological risks and enhancing co-benefits. This involves the development of novel methods to evaluate NBS measures for both before and after implementation. The framework can be used to guide the decision makers in the selection and evaluation of measures in river basin scale.

The framework consists of three stages. The first stage is to identify the main benefits and co-benefits of NBS that the project would like to achieve by using the RECONECT indicator selection tool. This selected indicators are used for both the selection of potential measures and the evaluation of implemented measures. The second stage is the ex-ante evaluation, which focuses on the planning process to define the potential measures that are considered effective. The final stage is Ex-post evaluation, which can be done in different ways such as comparing a baseline with monitoring data, interviewing stakeholders or collecting data in the field. The results of this evaluation will help to understand the effectiveness and impact of implemented measures. Ex-post assessment often introduces operational strategies in order to achieve the maximum benefits.

Each stage of the proposed framework will be applied to case studies in the RECONECT projects. The ex-ante evaluation will be applied to Collaborators, while the ex-post evaluation will applied to Demonstrators. The results will be presented in journal papers.

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References

1. World Economic Forum (2019) Global risks report 2019. Geneva, Switzerland
2. Guha-sapir D, Hoyois P, Below R (2015) Annual disaster statistical review 2014: The numbers and trends
3. Kishore N, Marqués D, Mahmud A (2018) Annual disaster statistical review. Cent Reserach Epidemiol Disasters/UCL

4. Gunderson L, Folke C (2011) Resilience 2011: leading transformational change. Ecol Soc
5. Matyas D, Pelling M (2015) Positioning resilience for 2015: the role of resistance, incremental adjustment and transformation in disaster risk management policy. Disasters. https://doi.org/10.1111/disa.12107
6. Cohen-Shacham E, Walters G, Janzen C, Maginnis C (2016) Nature-based solutions to address global societal challenges. In: IUCN commission on ecosystem management (CEM) and IUCN world commission on protected areas (WCPA): Switzerland. ISBN 9782831718125
7. Ruangpan L, Vojinovic Z, Di Sabatino S, Leo LS, Capobianco V, Oen AMP, McClain ME, Lopez-Gunn E (2020) Nature-based solutions for hydro-meteorological risk reduction: a state-of-the-art review of the research area. Nat Hazards Earth Syst Sci 20:243–270. https://doi.org/10.5194/nhess-20-243-2020
8. RECONECT About RECONECT Available online: http://www.reconect.eu/about-reconect/. Accessed 26 March 2020
9. Vojinovic Z (2015) Flood risk: the Holistic perspective. IWA Publishing, London, United Kingdom. ISBN 9781780405339
10. Alves A, Gersonius B, Sanchez A, Vojinovic Z, Kapelan Z (2018) Multi-criteria approach for selection of green and grey infrastructure to reduce flood risk and increase co-benefits. Water Resour Manag 32:2505–2522. https://doi.org/10.1007/s11269-018-1943-3
11. Raymond CM, Frantzeskaki N, Kabisch N, Berry P, Breil M, Nita MR, Geneletti D, Calfapietra C (2017) A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environ Sci Policy 77:15–24. https://doi.org/10.1016/j.envsci.2017.07.008
12. WMO (2007) Formulating a Basin flood management plan: a tool for integrated flood management. WMO
13. Ruangpan L, Vojinovic Z, Plavšić J, Doong D-J, Bahlmann T, Alves A, Tseng L-H, Randelović A, Todorović A, Kocic Z et al (2020) Incorporating stakeholders' preferences into a multi-criteria framework for planning large-scale nature-based solutions. Ambio. https://doi.org/10.1007/s13280-020-01419-4
14. World Wildlife Fund (2016) Natural and nature-based flood management: a green guide. Washington, DC
15. Alves A, Vojinovic Z, Kapelan Z, Sanchez A, Gersonius B (2020) Exploring trade-offs among the multiple benefits of green-blue-grey infrastructure for urban flood mitigation. Sci Total Environ 703:134980. https://doi.org/10.1016/j.scitotenv.2019.134980
16. Connop S, Vandergert P, Eisenberg B, Collier MJ, Nash C, Clough J, Newport D (2016) Renaturing cities using a regionally-focused biodiversity-led multifunctional benefits approach to urban green infrastructure. Environ Sci Policy. https://doi.org/10.1016/j.envsci.2016.01.013
17. Kabisch N, Frantzeskaki N, Pauleit S, Naumann S, Davis M, Artmann M, Haase D, Knapp S, Korn H, Stadler J et al (2016) Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge ... urban areas: perspectives on indicators, knowledge gaps, barriers, and. Ecol Soc 21. https://doi.org/10.5751/ES-08373-210239
18. Raymond CM, Pam B, Breil M, Nita MR, Kabisch N, de Bel M, Enzi V, Frantzeskaki N, Geneletti D, Cardinaletti M et al (2017) An impact evaluation framework to support planning and evaluation of nature-based solutions projects, Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas: Wallingford, United Kingdom
19. Gari SR, Newton A, Icely JD (2015) A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. Ocean Coast Manag
20. APFM (Associated Programme on Flood Management) (2015) Effectiveness of flood management measures-integrated flood management tools series
21. Liu Y, Theller LO, Pijanowski BC, Engel BA (2016) Optimal selection and placement of green infrastructure to reduce impacts of land use change and climate change on hydrology and water quality: an application to the Trail Creek Watershed, Indiana. Sci Total Environ 553:149–163. https://doi.org/10.1016/j.scitotenv.2016.02.116

22. Wang Q, Guidolin M, Savic D, Kapelan Z (2015) Two-objective design of benchmark problems of a water distribution system via MOEAs: towards the best-known approximation of the True Pareto front. J Water Resour Plan Manag 141:04014060. https://doi.org/10.1061/(ASCE)WR.1943-5452.0000460