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RECONECT

# Baseline assessment and potential for NBS in Collaborators

*Deliverable 4.2*

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| Abstract (for dissemination, 100 words) | This deliverable presents the baseline assessment and preliminary selection of measures in RECONECT Collaborator case studies, as one of the first steps of co-planning and assessment stage – the first stage of the social innovation approach in implementing NBS. The report includes baseline assessments for each Collaborator and a summary of findings across the Collaborators. It describes the methodological approaches and tools developed within RECONECT which can be applied in early stages of NBS implementation. It also highlights the importance of combining expert knowledge with stakeholder-based input because the perceptions on the NBS goals and benefits can strongly differ. |
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# Executive Summary

Baseline assessment and selection of potential nature-based solutions (NBS) is one of the first steps in the co-planning and assessment stage of NBS projects aimed at hydrometeorological risk reduction. This report presents such an assessment for the RECONECT Collaborator cases.

Each individual Collaborator report describes two main activities performed by the Collaborator partners: (1) assessment of baseline conditions, and (2) preliminary analysis of potential measures. The baseline assessment for each Collaborator case includes data and information needed for describing the hazards, including physical characteristics of the area (topography, land use, hydrographic network, soil and geological properties etc.), vulnerabilities, socio-economic conditions, political and regulatory context, main stakeholders, and existing and planned risk reduction measures. Preliminary selection of measures in Collaborator sites is made by applying the RECONECT methodology for selecting measures for reducing hydro-meteorological risks. This involves application of the corresponding Measure Selector tool and the tool for the multicriteria analysis (MCA) and ranking of the selected measures that uses the stakeholder opinions on the main benefits and co-benefits of NBS as the weights for the criteria. This approach therefore combines the knowledge of experts and professionals with the stakeholder views on the main challenges and goals.

This report analyses the individual Collaborator reports and provides a summary of the findings related to the development of baseline assessment and preliminary selection of measures. It lays out the scope and rationale of the baseline assessments, within the general stage of co-planning and assessment in implementation of NBS. Therefore, both project partners and a wider audience aiming at development of NBS projects can benefit from this report's methodological approach and from the recommendations provided.

The RECONECT methodology for selecting and ranking potential measures has shown to be a useful tool. The application of the methodology and the tools in Collaborator sites has shown that the preliminary selection for complex conditions may lead to a considerable number of appropriate measures. It is therefore suggested to reduce the preliminary number of the measures by relying on experts and professionals to eliminate the measures not suitable for the focus area, or to perform separate analysis for parts of the focus area with different characteristics. When engaging stakeholders for obtaining weights for criteria on different goals (benefits) of NBS in the MCA tool, a wider range of stakeholders from different groups should be involved in order to avoid bias and own assumptions on the rationale for NBS. Finally, the ranking of the measures based on MCA is a useful starting point for presenting the baseline assessments and the initially selected measures to the stakeholders in validation workshops while also introducing the benefits and co-benefits of particular NBS.

**Due to the large file sizes, the deliverable does not include individual reports. However, these reports can be made available upon request.**

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# 1 Introduction

## 1.1 Background

Implementation of nature-based solutions (NBS) for hydro-meteorological risk reduction offers the possibility to break away from traditional practices and enable to reconnect our land management practices and developments with nature in order to achieve multiple benefits to services and functions of ecosystems. According to Olsen & Bishop (2009) and van der Nat et al. (2016), such measures are potentially more cost-effective and adaptable than traditional hard engineering measures. However, cost-effective design and implementation of NBS is only part of the answer. Of equal importance is the ability to effectively place them in diverse local and cultural contexts and integrate them into broader land and risk management strategies. It is therefore of crucial importance to understand the complexity of each case and to design the NBS in a way that minimizes social and economic losses and environmental impacts, increases resilience to hydro-meteorological hazards while achieving multiple co-benefits, and ensures upscaling, business models and financial viability of any interventions. Examples of large scale NBS for disaster risk reduction (DRR) which can provide proof-of-concept for their upscaling and replication is currently lacking and there is a clear need to enhance their evidence base through demonstration within the European reference framework.

RECONECT is an interdisciplinary international project that aims to contribute to European reference framework on NBS by demonstrating, referencing and upscaling large-scale NBS and by stimulating a new culture for land-use planning that links the reduction of risks with local and regional development objectives in a sustainable way. Furthermore, an important element in RECONECT is its social innovation approach, underpinned by co-creation as the means for effective stakeholder participation in different stages of the NBS implementation process: co-assessment and planning, co-design and implementation, co-monitoring, and co-evaluation.

In order to contribute effectively to the EU reference framework on NBS, to generate higher impacts across Europe, and enable learning and upscaling internationally, RECONECT draws upon a number of Demonstrator and Collaborator sites (Figure 1). These have been carefully selected to cover a range of local criteria including (1) climatic and geographic conditions, (2) type of hydro-meteorological hazards (floods, storm surges, droughts, landslides), (3) vulnerability to these hazards, and (4) governance structures and social/cultural settings. Besides these criteria, the potential for collaboration and upscaling has also played a role in the selection process. The Demonstrators type A are the cases where the co-creation of NBS will be carried out during the project, while Demonstrators type B are the cases where such works are already implemented and will serve as the reference cases.

The Collaborator cases in RECONECT are envisaged as the cases inspired by the Demonstrator sites. The pool of Collaborator cases consists of European and International Collaborators (see Table 1). By sharing the RECONECT knowledge and experience with the Demonstrators, the main activity of the Collaborators is the development of the pre-feasibility studies for implementation of NBS in their focus areas. The Collaborators' prefeasibility studies will explore application of potential NBS and their benefits and co-benefits compared to the baseline conditions, also by incorporating RECONECT knowledge on co-planning and co-design. These studies are aimed at providing a proof-of-concept for NBS in local environmental and societal settings in each Collaborator site while also serving as a primer in replication in the Collaborator countries.

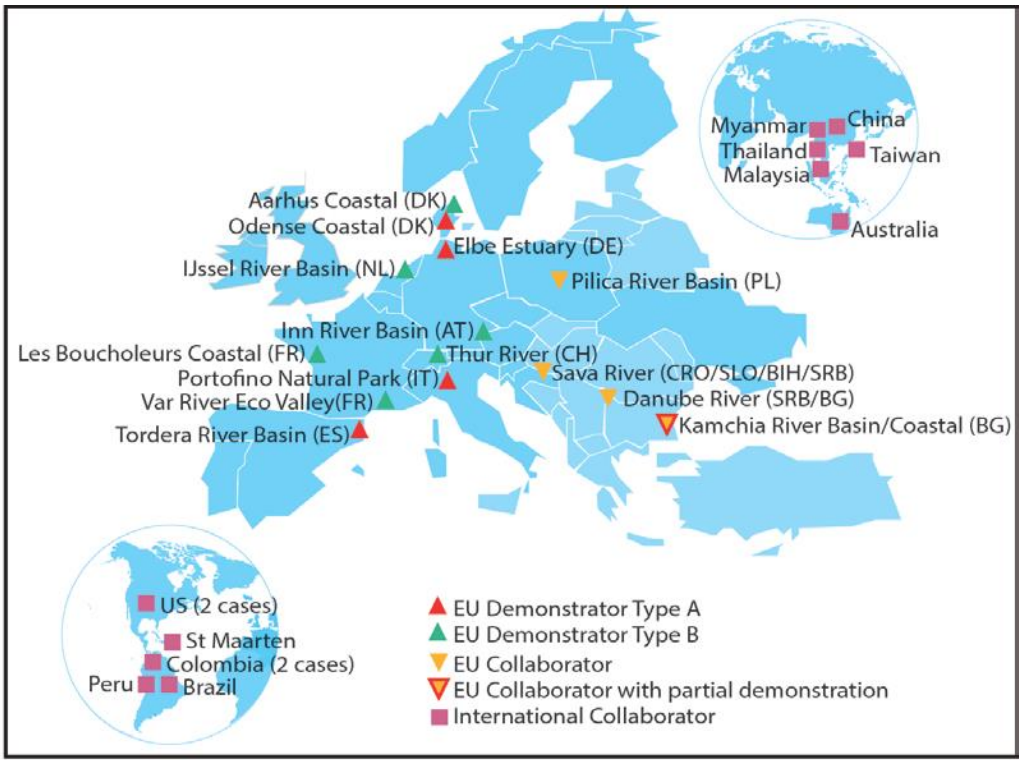



*Figure 1. RECONECT network of cases*

## 1.2 About of this report

This report is a part of RECONECT's work package 4 on "Overcoming barriers, upscaling and synergies with Collaborators" and it summarises the work in Task 4.2, which deals with assessing the baseline conditions and exploring the potential for NBS in the Collaborator sites. As such, it makes one of the first steps in the co-planning and assessment stage for implementing NBS in Collaborator sites. Table 1 lists Collaborator cases for which this activity was performed and for which the individual reports were prepared.

Each individual Collaborator report describes two main activities performed by the Collaborators: (1) assessment of baseline conditions in the selected focus area (baseline assessment), and (2) preliminary analysis of potential measures (potential for NBS). These individual reports are not a part of this summary report but can be made available at request.

This report analyses these individual reports and provides a summary of the findings. In the next section, it first presents RECONECT's general framework for implementation of NBS based on co-creation and explains how this procedure is applied for the Collaborator sites within RECONECT, including a brief description of the methodology to prepare the baseline assessments and perform preliminary selection of measures. Section 3 gives an overview of the baseline assessments of the Collaborators focus areas and summarises their main features. Section 4 focuses on the potential for NBS in Collaborator sites, explains the application of the methodology for screening and selecting potential measures based on the Measure Selection Tool and multicriteria analysis, and describes the results in Collaborator sites. Final section gives a brief outlook on identified challenges and provides some recommendations for further work.

The report can be useful for the researchers within and beyond RECONECT who are interested in understanding the data requirements to carry out an assessment and initial planning of potential NBS. More generally, the report might be of interest to actors working with aspects related to water governance, risk management, hydrometeorological hazards and spatial planning.

*Table 1. Collaborator sites in RECONECT*

Note: * Collaborators with individual reports on Baseline assessment and potential for NBS.

| Collaborator | Country | Responsible partner |
|---|---|---|
| EUROPEAN COLLABORATORS | | |
| *EC-1: Kamchia River Basin (with Estuary) | Bulgaria | BDCA, VARNA |
| *EC-2: Pilica River Basin, focus on the Luciaza river | Poland | Warsz, ERCE |
| *EC-3: Sava River Basin with tributaries<br>a. Bosut<br>b. Drina<br>c. Kolubara<br>d. Vrbanja | Croatia, Serbia, Bosnia & Herzegovina | PRONING, UNBELGR, IWACONS |
| INTERNATIONAL COLLABORATORS – Asian Collaborators (funded from the project) | | |
| *IC-1: Chao Phraya River Basin | Thailand | HAII |
| *IC-2: Nangang River | Taiwan | NCKU |
| *IC-4: Cameron Highlands | Malaysia | UPM |
| *IC-6: Myittha River basin | Myanmar | SEI |
| *IC-7: Sungai Selangor River Basin | Australia | MONASH |
| INTERNATIONAL COLLABORATORS – South American Collaborators (not funded from the project) | | |
| IC-3: Rio Comprido, Jacarei | Brazil | TUHH |
| IC-10: Piura River Basin | Peru | TUHH |
| IC-11: Rio Frio, Magdalena | Colombia | IHE |
| *IC-12: Cañaveralejo, Lili and Melendez River basins | Colombia | IHE |
| IC-13: St. Maarten | The Caribbean | IHE |
| *IC-14: Heliodora basin | Colombia | IHE |

## 1.3 Links to other RECONECT reports

This deliverable (D4.2) builds on the following RECONECT deliverables:

- D1.2 – Social Innovation Approach. This deliverable explains the RECONECT's co-creation approach and its stages. Preparing baseline assessments and preliminary selection of NBS are the part of the first stage, co-planning and assessment.
- D1.4 – Guidance document on integrating innovative NBS technologies into existing landscape, maintenance issues and long-term sustainability. This deliverable defines the RECONECT's implementation framework for NBS interventions and explains its phases.
- D1.5 – Selection and enhancement of supporting tools/models/DSS for NBS implementation and evaluation. The Measure Selection Tool for selecting suitable NBS based on the general criteria has been used in the Collaborator partners' work.
- D1.7 – Final report on holistic ecosystem based framework.
- D2.6 – Co-monitoring and co-evaluation plans for Demonstrators A and B.

- D4.1 – Stakeholder mapping and analysis in Collaborator sites. Stakeholders identified in D4.1 were also involved in the preliminary selection of NBS for Collaborator sites by providing their opinions on main goals and subgoals related to implementation of NBS.

This deliverable will primarily feed into the outputs of Task 4.8, Prefeasibility studies for Collaborator sites. Each Collaborator will build its prefeasibility study from the individual baseline assessment and selection of measures. The summary report will feed into all remaining tasks of WP4.

# 2 Methodology

Analysis of baseline conditions and potential for NBS in the Collaborator sites follows the methodology prepared within RECONECT in line with its holistic framework for assessment of NBS and its commitment to pursuing stakeholder engagement through co-creation of NBS. First subsection of this methodological part provides an overview of RECONECT's general frameworks for co-creation and implementation of NBS, while the second subsection explains the methodology by which the Collaborator partners prepared their individual reports.

## 2.1 RECONECT approach to co-creating NBS

As described in deliverable D1.7, RECONECT's **holistic framework** for assessment of NBS (Figure 2) considers actions and interactions within and between natural environment and socio-technical systems, which co-evolve through decisions on how to use and develop these systems. The hydrometeorological risks (from floods, droughts, landslides, etc.) therefore emerge from these interactions, because the risks are also affected by the social systems (actors, behaviour, institutional structures) as well as the technical systems (flood mitigation systems, agricultural systems, urban infrastructure, etc.). Nature-based solutions are a part of the socio-technical systems with specific interdependencies within these systems (e.g., social and cultural acceptance, land planning, market demand), and with specific interactions with the natural system (e.g., hydrometeorological hazards, climate change, ecosystems degradation). Consequently, the benefits and co-benefits of NBS interventions also emerge from interactions within and between the socio-technical systems and the natural environment, and should therefore be holistically evaluated in terms of three main challenges (water, nature, people) in both time and space dimensions.

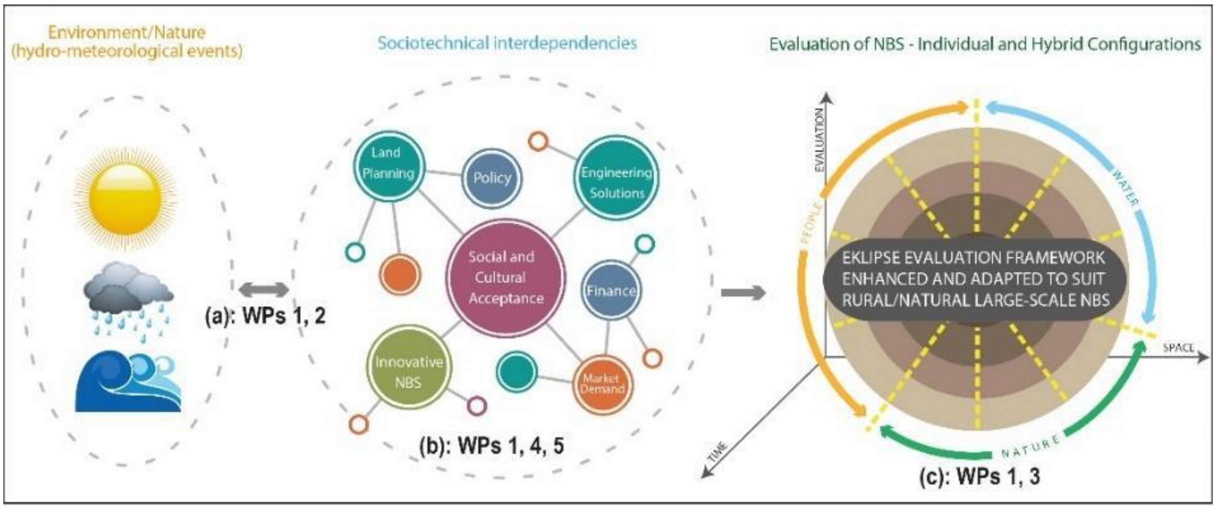



*Figure 2. Schematic of RECONECT holistic ecosystem-based framework*

Source: RECONECT deliverable D1.7

Because NBS interact significantly with the social systems, an important dimension of RECONECT is its **social innovation approach**, outlined in D1.2. This approach promotes active engagement of stakeholders in generating new and more effective solutions to complex societal and environmental challenges related to management of hydrometeorological risks, adaptation and mitigation of climate change, and restoration of degraded ecosystems. The social innovation is operationalised by involving stakeholders in the process of **co-creating** NBS, i.e., by engaging them in all stages of developing NBS (Figure 3). These stages include co-planning and assessment, co-design, co-implementation, co-monitoring and evaluation, and finally, upscaling, as the process in which social innovation leads to a transformative change and allows NBS to be more widely adopted.

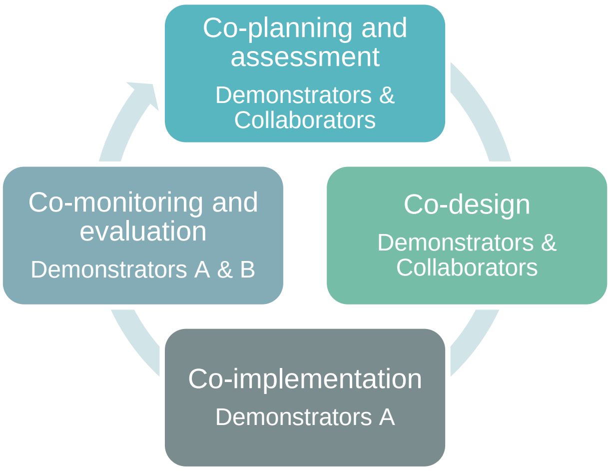



*Figure 3. Co-creation of NBS: active engagement of stakeholders in different stages of NBS realisation.*

Realisation of NBS interventions and projects differs from the traditional projects for several reasons. Because NBS have potential to address multiple challenges and provide multiple benefits and co-benefits, the projects involving NBS should be dedicated to demonstrating the effectiveness of NBS in relation to different challenges (sublimed in RECONECT's three main challenges: water, nature and people). This leads to greater project complexity and calls for carefully defined project objectives and expected impacts. Uncertainties inherent in natural process are also contributing the complexity of NBS projects and indicate the need for monitoring of the NBS effects through time and for applying adaptive management actions.

RECONECT's **framework for implementation of NBS** is outlined in deliverable D1.4, with the following main phases (Figure 4):

I. **Inception phase** considers the context for planning of NBS (identifies the challenges), prepares for the co-creation process, and defines the objectives of the implementation.

II. **Situation analysis** assesses all relevant factors influencing the NBS implementation. Typically, maps of relevant hydrometeorological hazard and risk are developed for current situation and for relevant future scenarios. Preliminary screening of the relevant measures is performed in accordance with the expected impacts for the given conditions.

III. **Strategy building** defines the NBS/hybrid solutions alternatives by performing an in-depth analysis of the pre-screened measures in the previous step. For all alternative strategies it is necessary to assess associated hazard and risk and to understand the opportunities of the proposed measures in terms of providing performance that would lead to achieving the objectives. The preferred strategy is derived through a comprehensive multicriteria analysis that incorporates stakeholders' evaluations.

IV. **Action planning** includes the investment planning by balancing costs, risks and performance. A more specific assessment and design of the adopted solution is performed, and a robust monitoring program is developed with the objective to monitor and evaluate the performance of the selected measures in terms of benefits and co-benefits.

V. **Implementation** of NBS encompasses the activities of construction, placement of the required equipment, subsequent operation and maintenance actions. Throughout the implementation process, monitoring and evaluation of the effects of the adopted NBS/hybrid solution takes place and is compared to the baseline conditions prior to the implementation.

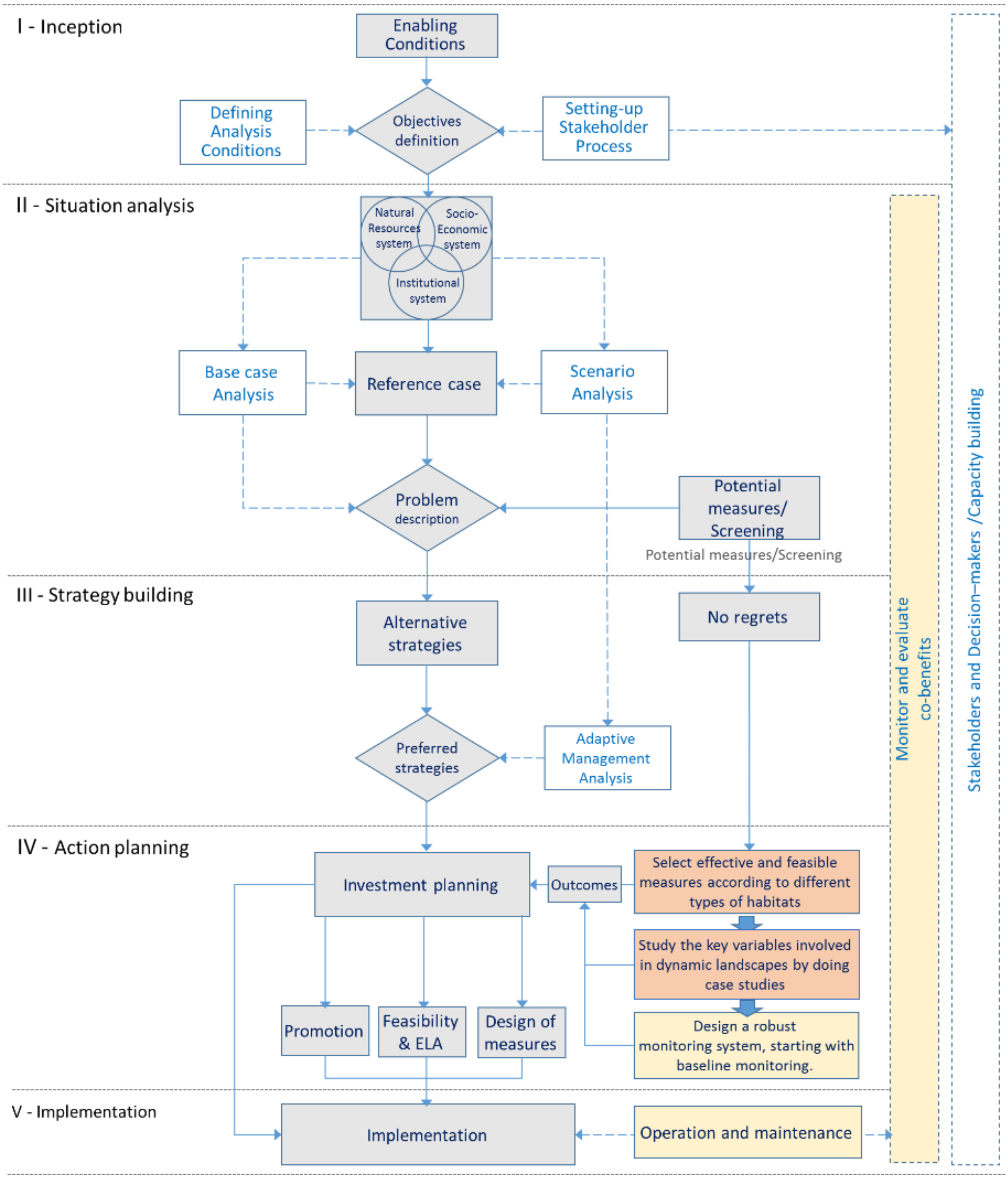



*Figure 4. Framework for the implementation of NBS*

Source: RECONECT deliverable D1.4

The first three phases of this framework (inception phase, situation analysis and strategy building) correspond broadly to the co-planning and assessment stage of the co-creation process, while the fourth and fifth phase are related to co-design and co-implementation stages. The co-monitoring and evaluation take place throughout the implementation process to collect data and assess the benefits and co-benefits of the proposed solution in comparison to the baseline or reference conditions.

## 2.2 Co-planning and assessment of NBS in Collaborator sites

The role of Collaborators in RECONECT is to get inspired by Demonstrators, use RECONECT methodologies and tools, and initiate the process of co-creating NBS for their cases by completing the co-planning and assessment stage and developing prefeasibility studies (or preferably going further into the implementation process).

The activities in Collaborator sites towards preparing prefeasibility studies, corresponding to the RECONECT's framework for implementation of NBS, are shown in Figure 5.

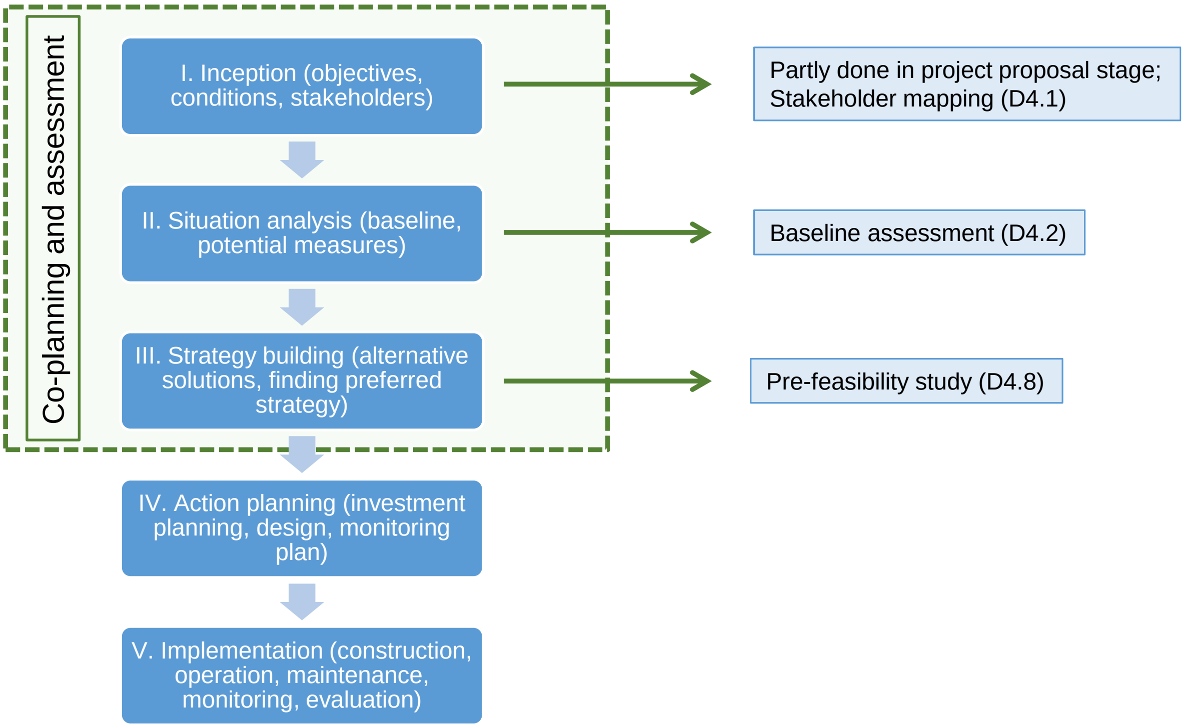



*Figure 5. Collaborators' workflow to prepare pre-feasibility studies in the context of RECONECT's framework for implementation of NBS.*

Inception phase for the Collaborator cases was partly accomplished during the RECONECT project proposal period. The Collaborator sites were selected by the project partners based on the existing knowledge on previous hazard history and related challenges in these areas, so that the key problems and general context for these cases was known at the beginning of the project.

Identifying stakeholders was the first activity for the Collaborator cases within the project. This activity was performed under Task 4.1 of WP4 and is reported in deliverable 4.1. This was followed by interaction with the stakeholders (usually in meetings, presentations, discussions) that allowed shaping of the objectives for each case.

Situation analysis is the phase when all relevant elements of the natural environment and the socio-technical system reflecting pre-intervention (baseline or reference) conditions should be assessed in order to understand relevant factors and interactions influencing implementation of NBS. Assessing the baseline conditions also helps to identify potential measures for resolving the identified challenges and meeting project objectives.

For the RECONECT Collaborator cases, this work is comprised in the **baseline assessments** with preliminary analysis of **potential for NBS**. This is the subject of this deliverable and is covered in the subsequent sections in more detail.

Further work towards the development of the pre-feasibility studies for Collaborators is a part of the strategy building phase of the NBS implementation framework. This phase will include preparation of several alternative sets of NBS/hybrid measures aimed at identified goals, and a comprehensive analysis and evaluation of their effects. The methodological approach for this work is under development and will be presented in deliverable D4.8. An outcome of this phase should be to identify preferred solution for reducing hydrometeorological risks in the focus area.

Although this phase implicates significant technical work (e.g., numerical modelling needed for preparation of hazard maps), it should also involve stakeholders in the process to ensure that the proposed solution is not only suitable and feasible, but also sustainable and acceptable by stakeholders (to be subject of deliverable D4.5).

## 2.3 Baseline assessment

For the NBS interventions aimed at hydrometeorological risk reduction, the baseline conditions in the focus area should be scrutinized with an aim to assess pre-intervention hazard magnitudes, vulnerabilities and all relevant factors affecting the risk(s). Information from the baseline assessment is used later for evaluation of performance of the proposed solution by comparing the pre-intervention and post-intervention conditions.

In the planning stage of a NBS project, information about the history of hazards in the focus area, as well as about its physical features (climate, topography, geology, land cover and use, etc.) and socio-economic characteristics (vulnerabilities, development plans, regulatory context), is crucial. Collecting data and information not only helps to learn about the mechanisms that contribute to the hazards and risks in the area but is also important for understanding possible effects of the potential NBS measures on particular risk components. Baseline data collection is therefore essential for any future evaluation of NBS performance.

Because of the multiple dimensions of the expected NBS outcomes, it is vital that the baseline assessment covers all aspects that are important for demonstrating the benefits of the proposed solution in the co-evaluation stage (i.e., lack of the baseline data may lead to impossibility to evaluate certain benefits from NBS and consequently limit their value). This means that the indicators related to the main challenges should be carefully selected to allow both ex-ante and ex-post evaluation.

The “RECONECT indicator assessment methodologies” for the three main challenges (WATER, NATURE, and PEOPLE) are developed within WP3 (see also deliverable D2.6 for monitoring and evaluation plans for the Demonstrator sites), while RECONECT’s co-evaluation framework is under development.

At the time when the work on the baseline assessments of Collaborator sites has started, the RECONECT indicators have not been fully developed, so the data and information that describe the baseline conditions in Collaborator sites were chosen according to the common practice in risk assessment studies. Although data and/or analysis needed to quantify and describe the hazards, socio-economic conditions and the impacts from the hydro-meteorological hazards depend on the type of the phenomena (riverine floods, flash floods, landslides, droughts, etc.), a common list of characteristics was prepared for all Collaborator sites. This includes:

- Current risks and hazard types
- Hazard history
- Terrain topography
- Soil and geology

- Drainage system
- Groundwater
- Wetlands, lakes, ponds, marshes
- Land cover and land use
- Vulnerabilities (physical, economic, environmental/ecological, social, institutional)
- Measures for risk management
    - Existing measures (structural and non-structural)
    - In progress and planned measures (structural and non-structural)
- Stakeholders
- Future development plans (infrastructure, transportation trends, economic trends)
- Political and regulatory context (incl. relevant policies)

Section 3 gives an overview of the main characteristics of the Collaborator sites.

## 2.4 Potential for NBS

Selecting appropriate measures for reducing hydrometeorological risks for a focus area is a complex decision-making process, which is supposed to balance between multiple objectives, criteria, and conflicting interests of different stakeholders. Assessing the baseline conditions helps to identify potential measures for resolving the identified challenges and meeting project objectives. Various measures, including NBS, grey infrastructure and hybrid solutions, can generally meet the objectives set to target identified challenges. Preliminary selection of measures can be made from past experiences or based on the literature reviews and recommendations (Ruangpan and Vojinovic, 2021), but will generally depend on the specific local conditions in the focus area.

The selection of measures should also be a part of the co-creation process, which not only helps to enhance the awareness and knowledge of citizens and stakeholders around NBS and their co-benefits, but also contributes to inclusiveness in decision-making for sustainable solutions and land use transformation (Mahmoud and Morello, 2021).

In the co-planning and assessment stage of NBS projects, evaluating a long list of potential measures with high technical detail may not be feasible nor justifiable. Even if this process would not be resource-consuming, considering numerous measures would make the decision-making process very difficult. Therefore, a longer list of potential measures should be subject to a screening process from which only the measures suitable and applicable for the local settings would be selected and processed in more detail.

The analysis of potential NBS measures in Collaborator sites is based on the methodology developed within RECONECT. The methodology, illustrated in Figure 6, consists of two main parts:

(1) preliminary selection of measures (screening) from the RECONECT catalogue of measures using the Measure Selection tool, and

(2) a multicriteria analysis (MCA) of the potential measures, which incorporates stakeholders' preferences about different goals.

The first step of the methodology allows to select the measures which are generally suitable for the focus area. The second step puts weight to each selected measure based on the stakeholder preferences about main goals and subgoals related to water, nature and people as the main challenges, and consequently allows the measures to be ranked according to these scores and the list of measures to be shortened. Such an approach can then be followed by a more detailed analysis that could consider cost-effectiveness and feasibility of the measures, thus facilitating the decision-making process of implementing NBS. The following subsections describe these two methodological steps in more detail.

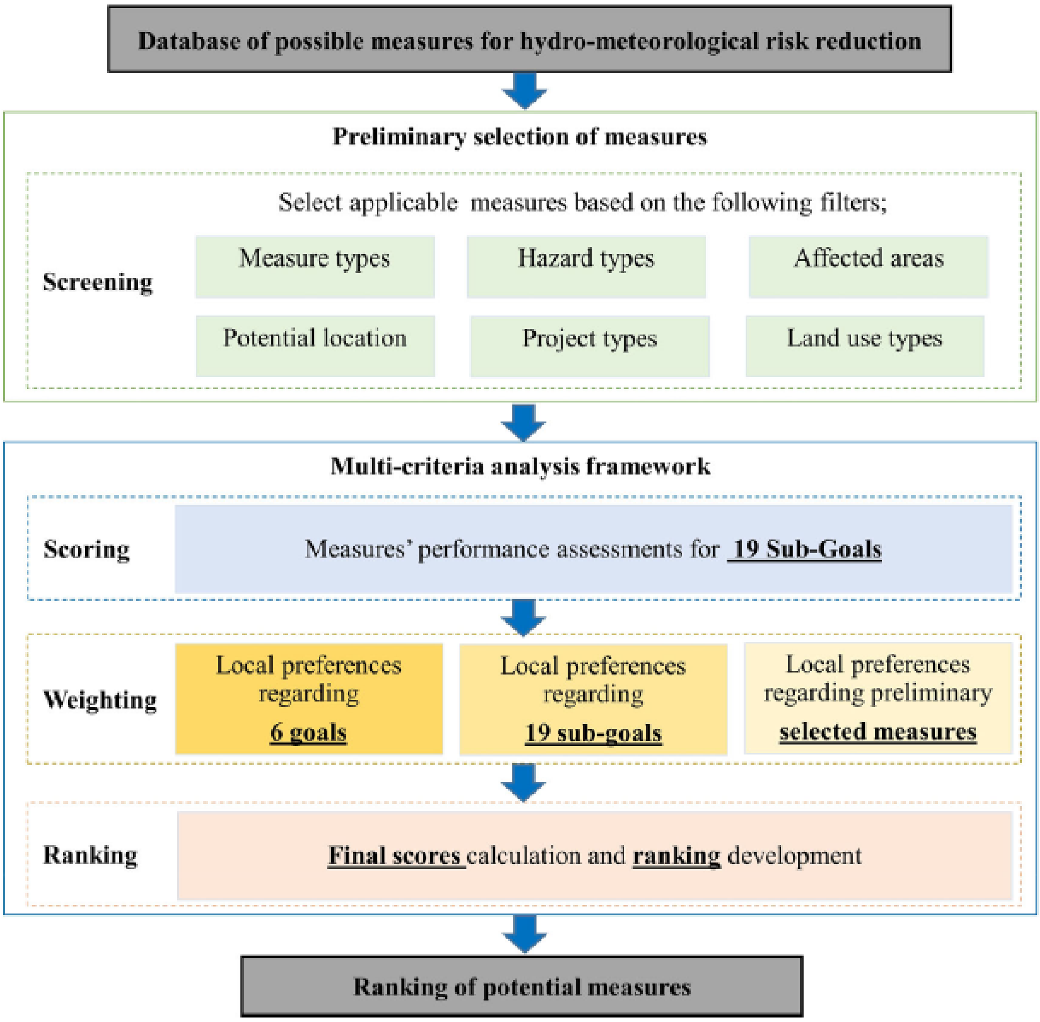



*Figure 6. RECONECT methodology for selecting potential NBS.*

### 2.4.1 Preliminary selection of measures

For the purpose of preliminary selection, the Measure Selection Tool has been developed in RECONECT (Figure 7). Using the tool, preliminary selection of measures is made from the catalogue of measures based on six filters (criteria), such as the hazard type, land use type, location within a basin, etc. Figure 8 shows the available criteria in the tool and the possible choices for each filter.

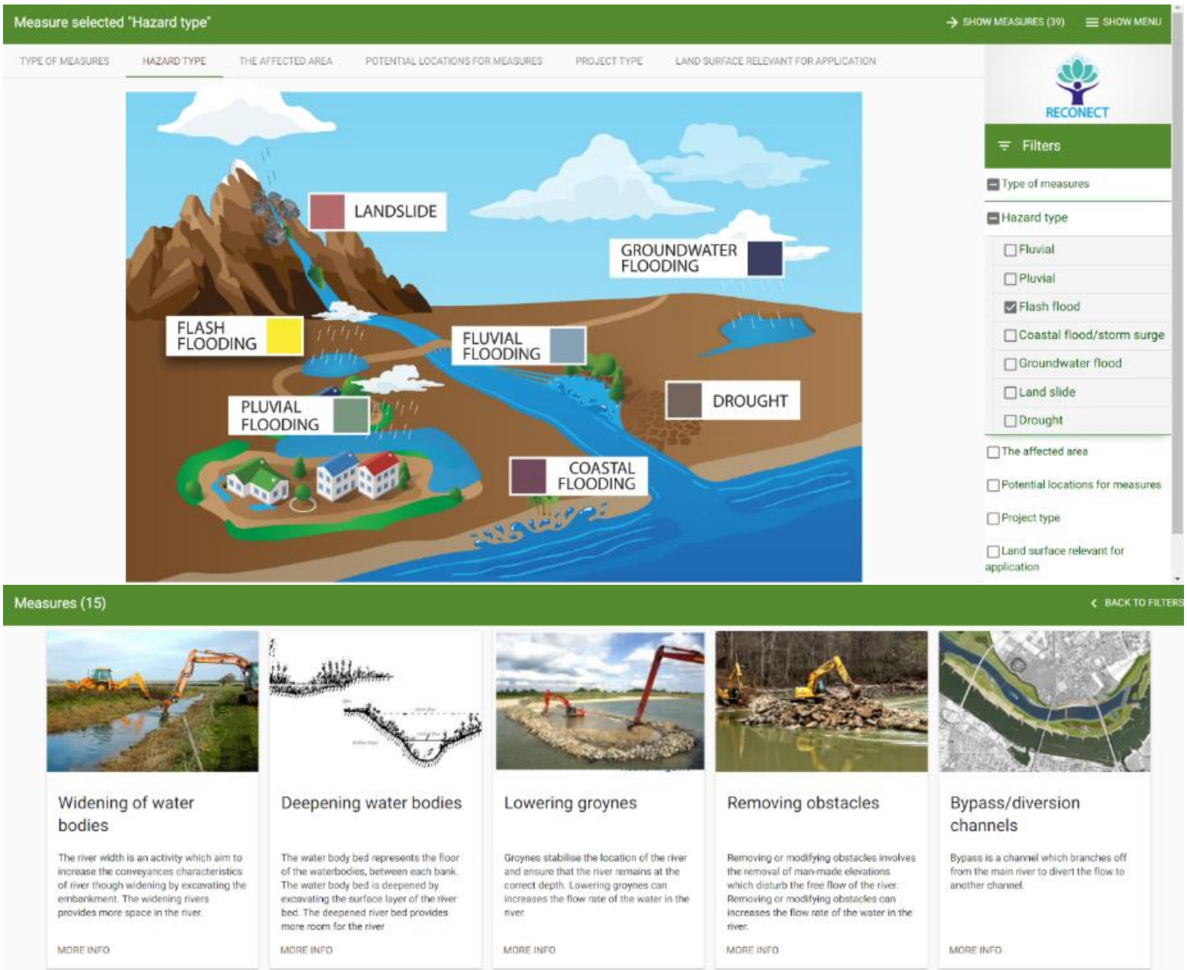



*Figure 7. RECONECT tool for selection of measures: screen shots showing an example of the filters for hazard type (top) and part of the selected measures (bottom).*

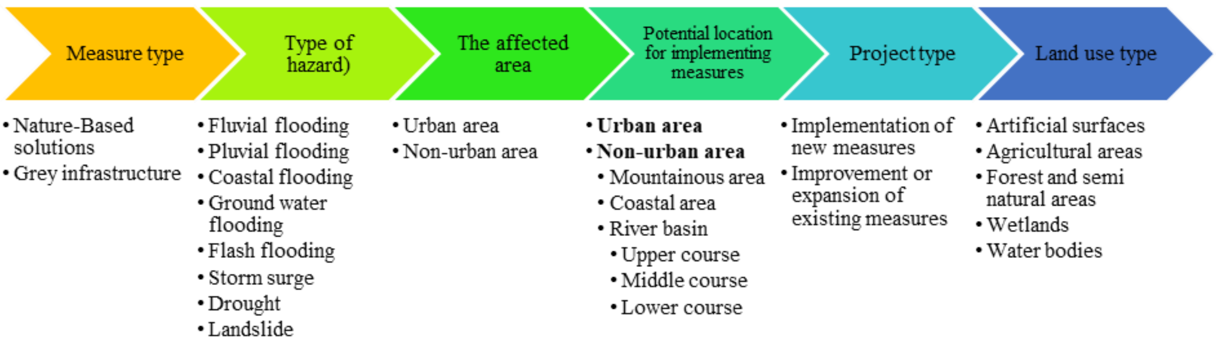



*Figure 8. Criteria for selecting measures in the RECONECT Measure Selection tool.*

Once the preliminary list of generally suitable measures is obtained, it can be further reduced to the measures suitable for the focus area. For example, deepening of the river bed is one of the possible measures to mitigate riverine floods; if, however, such a deepening of a tributary would create an undesirable denivelation in relation to the main river, this measure is not applicable to the focus area in question. For each Collaborator site, this second selection process was made based on the expert opinion of partners responsible for the site. The second screening and potential elimination of some measures can also be done at this stage with the help of stakeholders, if there are reasons in the area that prevent implementation of such a measure. For example, if there is a strong opposition of local citizens against high (concrete) dams of detention basins while there are other as effective solutions, the measure can be excluded at this stage.

### *2.4.2 Ranking of measures by MCA*

Multicriteria analysis (MCA) is a standard framework for decision-making with multiple objectives. It is especially applicable for those decision-making processes in which environmental and social impacts cannot be assigned monetary values. At the same time, MCA allows including a full range of social, environmental, technical, economic, and financial criteria (TEEB, 2010).

The methodology for selecting measures in RECONECT uses a MCA framework and incorporates in it stakeholders' preferences for main goals and subgoals. Involving stakeholders into the process of selecting measures allows introducing additional relevant local information that might otherwise be unnoticed/disregarded by the engineers (Ruangpan et al., 2021). In this way, a selection of the most suitable and effective measures for a specific area and hazard type is ensured. This is important for the successful implementation and sustainable exploitation of a specific measure and, therefore, for long-term risk reduction and effective water resources management. Another highlight of this methodology is that it includes a wide range of criteria for both main benefit (reduction of hydro-meteorological risks) and co-benefits (improvement of water quality, protection and enhancement of habitats, safeguard of biodiversity and socio-economic and human wellbeing.

In RECONECT, the objectives of the NBS measures are also referred to as goals and sub-goals. The goals represent the main objectives within the WATER, NATURE, or PEOPLE challenge area (e.g., water quantity, water quality, habitat structure, biodiversity, socio-economics and human well-being), whereas the sub-goals are subthemes within those goals and reflect more specific NBS project objectives (e.g., flood risk reduction within the water quantity goal). For each of these relatively broad objectives, a number of indicators and variables are specified for the purpose of evaluating NBS (see also deliverables D1.3 and D2.6). This hierarchical structure is shown in Figure 9, while the goals and subgoals for the three main challenges are given in Table 2.


*Figure 9. Hierarchy of objectives and indicators for NBS evaluation in RECONECT*

Source: Ruangpan and Vojinovic, 2021

*Scoring.* Performance of NBS and their potential effects in terms of the goals/subgoals is defined by the scores, which are defined through an assessment of quantitative and qualitative data from literature and expert judgements. The scores range from 0 (no impact) to 5 (very high positive impact) and -5 (very high negative impact). Full overview of scores is given by Ruangpan et al. (2021).

*Weighting*. Stakeholders' opinions on the goals and subgoals are used to assess their preference of specific NBS. These preferences are translated into the weights for the goals/subgoals in the MCA framework (for details see Ruangpan et al., 2021). To obtain stakeholders' preferences, a questionnaire was prepared (Annex A) in which the stakeholders were asked to choose weight from 0 to 10 for each goal/subgoal and also provide their comments. Weight 0 indicates that the goal/subgoal is not important for the respondent, and weight 10 indicates high importance of the goal/subgoal for the respondent. In MCA, the weights are later normalised so that the sum of all weights for a goal is equal to 1.

*Ranking*. Final score for each measure is obtained as a weighted sum of the measure performance scores. Based on this, the measures can be ranked in context of the selected hazard types. The score for each measure is computed for all hazards and for each particular hazard.

The results of the preliminary selection and ranking of measures for Collaborator sites are discussed in more detail in Section 4.

*Table 2. RECONECT challenges, goals and subgoals*

| Challenge | Goals | Subgoals |
|---|---|---|
| **WATER** | Water quantity | Reduction of risk corresponding to the main hazard(s):<br>• Flood risk reduction in urban areas and around rivers, lakes, watercourses, etc.<br>• Coastal flood risk reduction<br>• Groundwater management<br>• Drought risk reduction<br>• Landslide risk reduction |
| | Water quality | Improve water quality in rivers/watercourses, lakes/ponds |
| | | Improve coastal water quality |
| | | Improve groundwater quality |
| **NATURE** | Habitat structure | Increase habitat area (quantity) |
| | | Habitat provision and distribution (quality) |
| | | To reflect ecological status and physical structure of habitats |
| | | Change in land use |
| | Biodiversity | Maintain and enhance biodiversity |
| | | Reduce disturbance to ecosystems |
| **PEOPLE** | Socio-economics | Increase recreational opportunities |
| | | Education and awareness about NBS |
| | | Maintain and, if possible, enhance cultural values |
| | | Accessibility (enhance use of the NBS area) |
| | | Improve community cohesion |
| | | Encourage new business models and other community benefits provided by NBS |
| | | Stimulate/increase economic benefits |
| | Human well-being | Direct health and well-being impacts |
| | | Indirect health and well-being impacts |

# 3 Baseline assessment of Collaborator sites

## 3.1 Overview of Collaborator case studies

The Collaborator sites are impacted by different natural hazards, but the hydro-meteorological hazards are causing most impacts along the basins. The Collaborator sites were carefully selected by the Collaborator partners during the project proposal phase having in mind previous hazards and main challenges in the area, as well as national priorities in addressing these challenges. In addition to having diverse conditions (from physical and climatic to socio-economic and institutional), the Collaborator cases included in RECONECT have been identified as the ones with interest and capacity to develop prefeasibility studies for implementation of NBS in their areas, and as the ones that could inspire other municipalities or regions to consider NBS in their risk management strategies, thus enabling further replication and upscaling.

While the main goal across all Collaborators is to protect the area from risks deriving from hydro-meteorological hazards, in some Asia-Pacific Collaborators there is also strong interest from local governments to find alternative solutions to grey infrastructure. In the Colombian Collaborators, there is an interest in implementing NBS to address other challenges in the area such as failure of drainage systems.

Tables 3, 4 and 5 summarize the information that each site provided as rationale for potential application of NBS in their focus areas, while the remainder of this section provides maps and basic information on each case.

*Table 3. European Collaborators rationale for NBS in their focus areas*

| EUROPEAN COLLABORATORS | | |
|---|---|---|
|  | **EC-1**<br>**Bulgaria**<br>**Kamchia River Basin** | The focus area is prone to fluvial, pluvial, and flash floods. Additional consultation was carried out with local stakeholders to identify high flood risk zones in the basin to define the specific site for NBS implementation. |
|  | **EC-2**<br>**Poland**<br>**Luciąża River Basin** | The Luciąża River Basin has dense hydrographic network that produces fast runoff, which contributes to the formation of floods at the mouth of the river and into the reservoir. A risk of agricultural droughts is also present in the upper part of the basin. |
|  | **EC-3a**<br>**Croatia**<br>**Bregana River Basin** | The Bregana River Basin has significant flood risk. It is also a tributary to the Sava River and a transboundary river between the Republic of Croatia and the Republic of Slovenia. |
|  | **EC-3b**<br>**Serbia**<br>**Jadar River Basin** | The Jadar River mostly flows through a flat and wide valley and along its course receives numerous torrential tributaries, which are prone to frequent torrential floods. The existing flood protection measures are not sufficient for flood management. |
|  | **EC-3c**<br>**Serbia**<br>**Kolubara River Basin** | The Kolubara River basin is prone to floods due to frequent simultaneous occurrences of torrential floods in the upper basin areas and high-water levels of the Sava River. Lower parts of the basin are highly urbanized preventing the river to expand. |
|  | **EC-3d**<br>**Bosnia and Herzegovina**<br>**Vrbanja River Basin** | The Vrbanja River basin is extremely susceptible to flash floods, with an increasing trend of flood flows in last 10-15 years. This basin also has a dominant impact on the risk in the downstream areas, which are flat and highly populated. |

*Table 4. Asian Collaborators rationale for NBS in their focus areas*

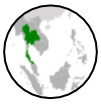
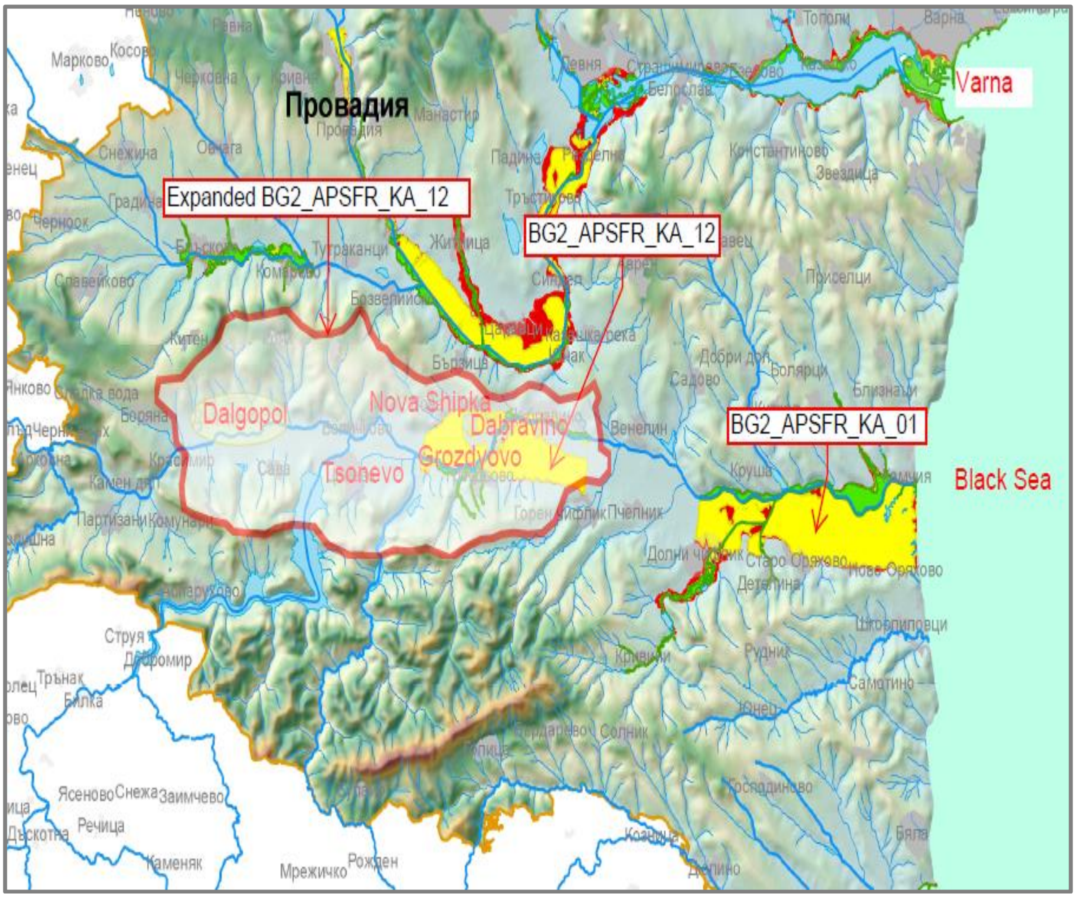
| ASIA-PACIFIC COLLABORATORS | | |
|---|---|---|
|  | **IC-1**<br>**Thailand**<br>**Chao Praya River Basin** | Flood and droughts are the main problems in the Chao Phraya River Basin. The focus is on the Rangsit irrigation network, built at the beginning of 20th century, that should be upgraded to continue to provide attenuation of floods and water for summer cropping. |
|  | **IC-2**<br>**Taiwan**<br>**Nangang River Basin** | The Nangang River has significant fluvial flooding risk. A grey solution proposed earlier by the government was rejected by local residents and abandoned. Therefore, there is a high interest in NBS in the area. |
|  | **IC-4**<br>**Malaysia**<br>**Cameron Highlands** | The extensive use of chemical fertilizers and pesticides by local farmers and the increased frequency of major storm events have led to soil erosion and landslide in the area. |
|  | **IC-6**<br>**Myanmar**<br>**Myittha River Basin** | Kale is one of the most flood-affected towns in Sagaing district, located in the valley of the Myittha River within the Chindwin River basin. The town is surrounded by mountains that generate floods affecting the assets and agricultural production. |
|  | **IC-7**<br>**Malaysia**<br>**Sungai Selangor River Basin** | The flood events in Sungai Selangor catchment are happening repeatedly, although their magnitudes are small and pose lesser problem than the high frequency. Therefore, nature-based solutions could be more suitable for catering to low intensity and high-frequency floods. |

*Table 5. Colombian Collaborators rationale for NBS in their focus areas*

| COLOMBIAN COLLABORATORS | | |
|---|---|---|
|  | **IC-12**<br>**Colombia, Cali**<br>**CaMeLi River Basins** | Flooding events in the Cañaveralejo, Meléndez, and Lili (CaMeLi) river basins affect large areas of the city Santiago de Cali, located in the foothill of the surrounding slopes of the basin. |
| | **IC-14**<br>**Colombia, Medellin**<br>**Heliodora River Basin** | Landslides and flash floods are frequent threats in the basin, which have caused several damages in the sewer system. NBS could be a potential solution to mitigate the consequences of the hazards for the sewer system. |

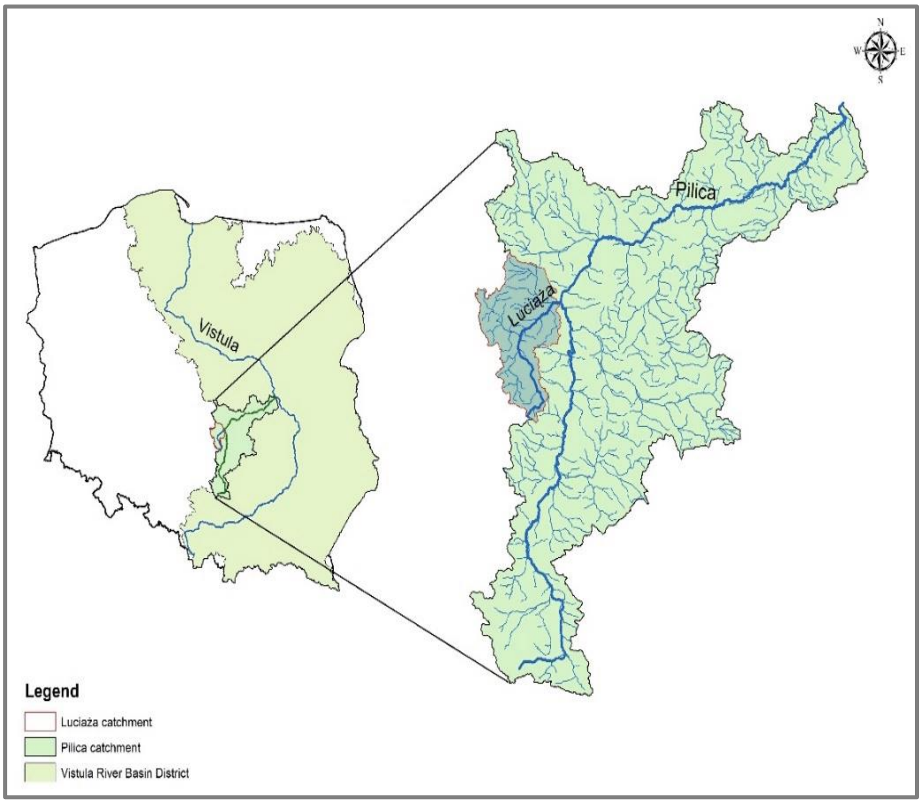
### *3.1.1 European Collaborators*

## EC-1: Kamchia River Basin, Bulgaria



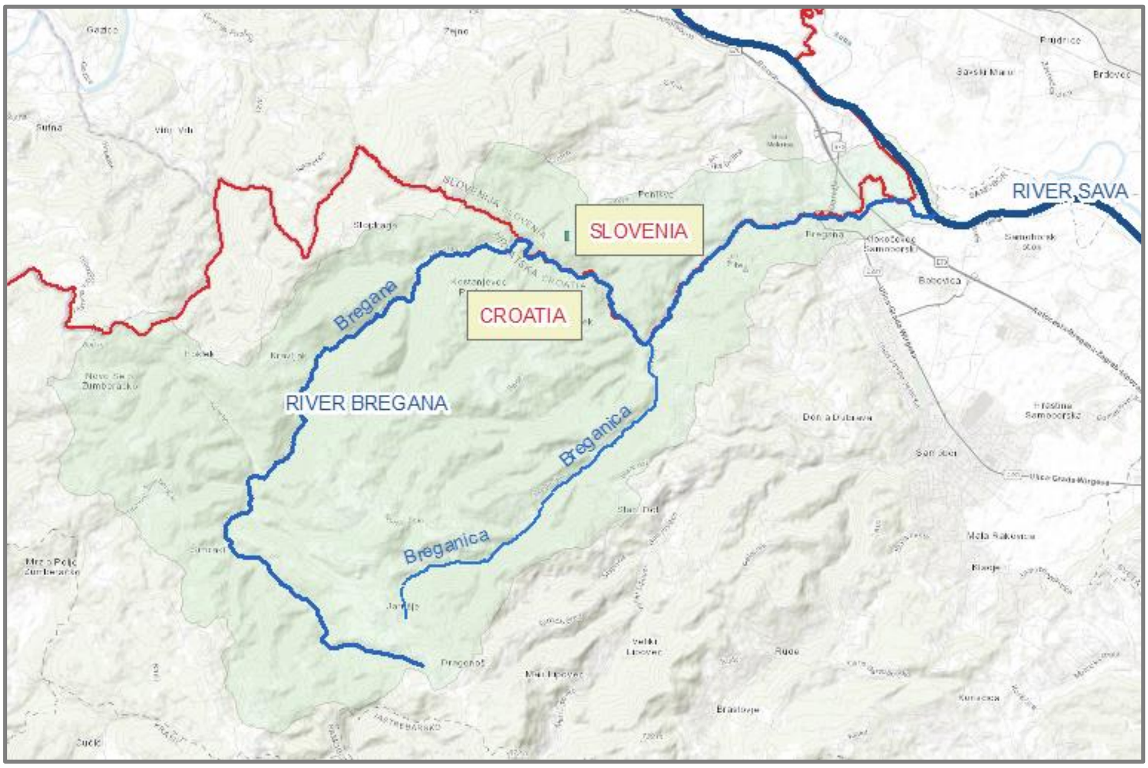

| | |
|---|---|
| **Climate** | Influenced by two climate zones Continental and Mediterranean. The mean annual temperature is around 12°C. In January, the mean temperature is -2°C and in July +25°C. |
| **Terrain topography** | Predominantly low mountainous. The highest point is peak Bulgarka (1181 m) in Slivenska mountain and the lowest Kamchia River mouth. |
| **Soil & geology** | Both mountainous and plain areas. In the mountainous areas the geology is mostly of karsts origin, while in the plain it is more siliceous based. |
| **Land cover & land use** | The basin is mostly covered by forest and agricultural land. |

## EC-2: Luciąża River Basin, Poland



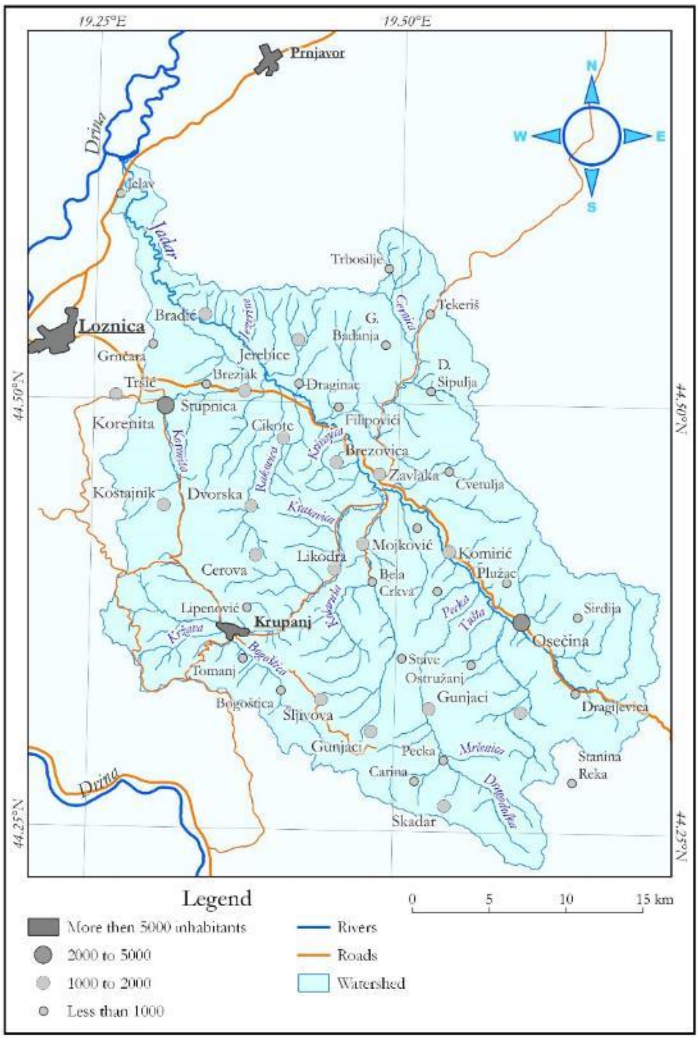

| | |
|---|---|
| **Climate** | Mean annual temperature of ca. 7.5 °C and mean January/July temperature equal to -4 °C and 18 °C. |
| **Terrain topography** | Elevation in the Luciąża basin varies from 285 m a.s.l. in the South in the spring section of the river to 165 m a.s.l. in the lowland area in the North of the valley. |
| **Soil & geology** | Mainly chalk marls covered with glacial formations. |
| **Land cover & land use** | Sandy soil predominate the soil cover in the basin. |

## EC-3a: Bregana River Basin, Croatia



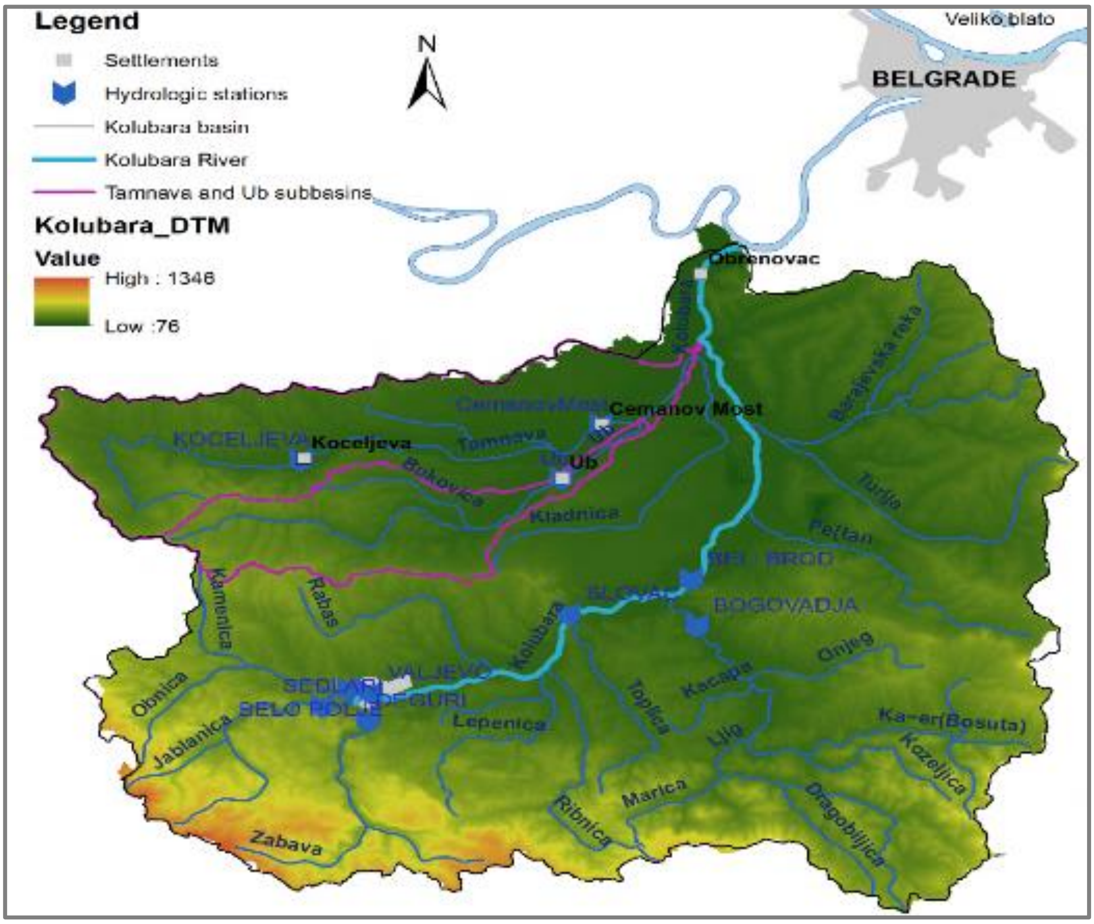

| | |
|---|---|
| **Climate** | Moderately warm rainy climate with a mean monthly temperature of the coldest month higher than -3 °C and lower than 18 °C |
| **Terrain topography** | Upper course -mountainous. Middle and lower - flood plain. Highest relief point of the basin is at an altitude of 859 m a.sl, while the lowest is at 130 m a.sl. |
| **Soil & geology** | Soil with a low degree of infiltration. Dominated by Rendiz on dolomite and limestone. |
| **Land cover & land use** | The basin is mostly covered by forest and agricultural land |

# EC-3b: Jadar River Basin, Serbia



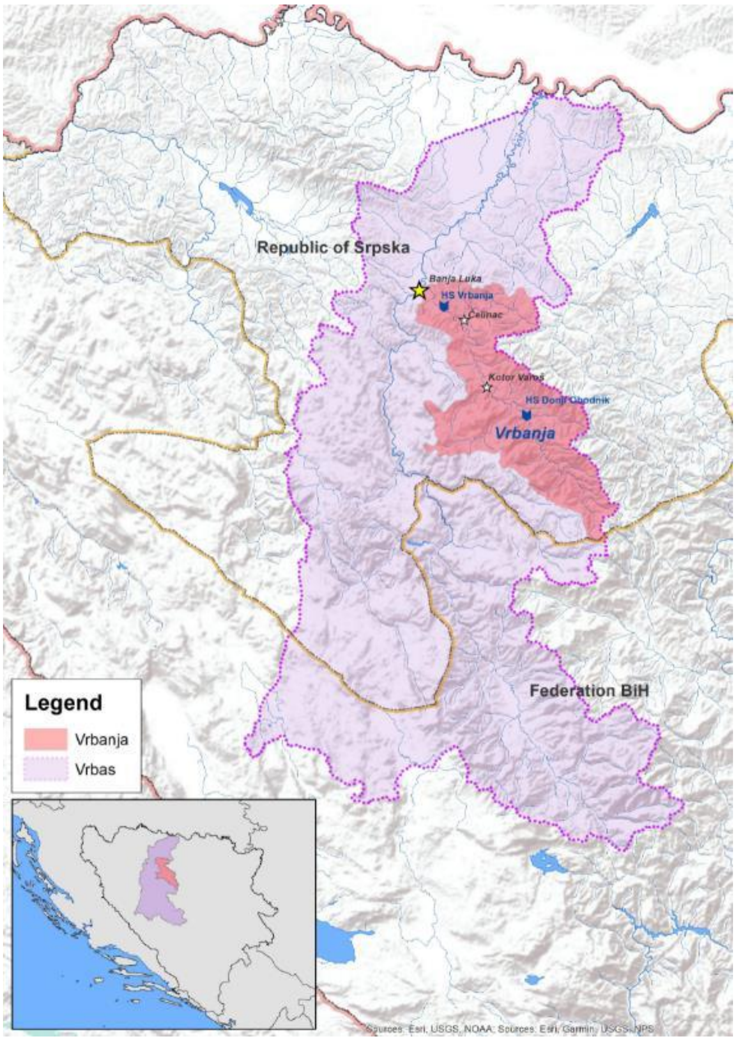

| | | |
|---|---|---|
| **Climate** | The winter can be severe with abundant snowfalls, while summer is hot and long. Average air temperature is estimated 10.4 °C. |
| **Terrain topography** | Mountainous at watershed and flat at the valley of the main river course. The mountains do not exceed 1000 m.a.s.l. in elevation. |
| **Soil & geology** | In lowland - Gravel, sand, and clay sediments deposited by the Drina and its tributaries. |
| **Land cover & land use** | Predominantly agricultural land |

## EC-3c: Tamnava River Basin, Serbia




| | | |
|---|---|---|
| | **Climate** | Mean annual temperature is 11.4 ºC. Mean temperature in the winter season is 1.5 ºC, and 21.9 ºC in the summer season. |
| | **Terrain topography** | Upstream -Mountainous and moderately hilly, |
| | **Soil & geology** | Downstream - lowland. |
| | **Land cover & land use** | Elevation ranges between 76 m.a.s.l. at and 1346 m.a.s.l. |

## EC-3d: Vrbanja River Basin, Bosnia and Herzegovina



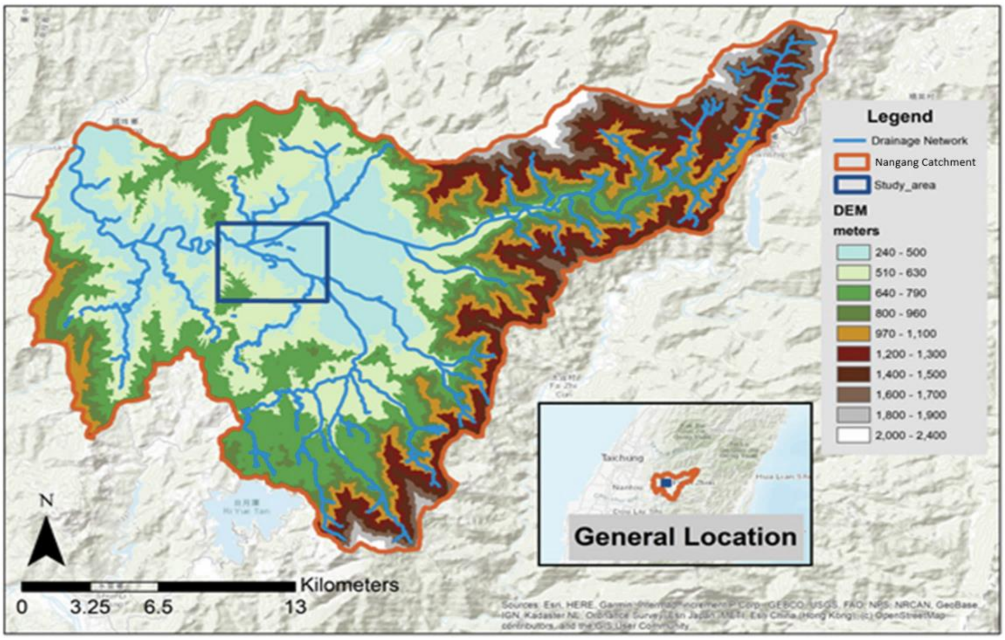

| | |
|---|---|
| **Climate** | Moderately humid subtropical climate with mild winters and warm summers. In the valley, mean annual rainfall is about 1,000 mm, while the mean The warmest month is August (20.5°C) and the coldest is January (0.6°C). |
| **Terrain topography** | Elevation ranges between 150 and 1,586 m a.s.l., with the mean basin elevation of 611 m. The head basin is mountainous with steep slopes and distinct topography; the middle river course is moderately hilly, and the lower course is in lowland. |
| **Soil & geology** | Mesozoic formations are present in the largest part of the area, and Neogene and Quaternary formations are developed on the basin periphery. |
| **Land cover & land use** | Forests are the prevailing land cover in the Vrbanja basin (61.46%). Pastures cover over 12% of the basin. The cultivated land is mainly owned by individual farmers working in extensive agriculture. |

### 3.1.2 Asia-Pacific Collaborators

**IC-1: Chao Praya River Basin, Thailand**

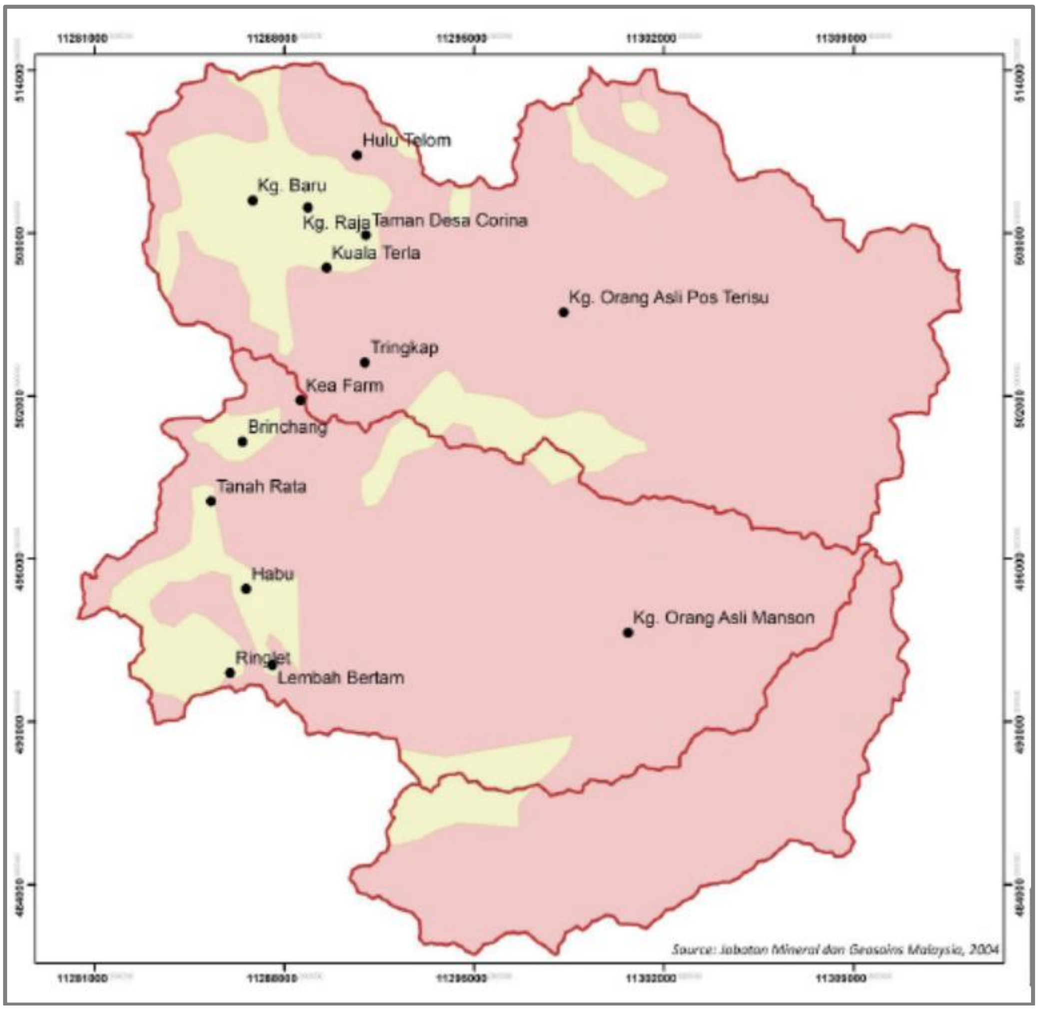

| | | |
|---|---|---|
| **Climate** | | Influence of monsoon winds of seasonal character where the climate is divided into three seasons i.e., Summer, winter and rainy. |
| **Terrain topography** | | The average terrain is rather flat with 4-5 meters above sea level. |
| **Soil & geology** | | Acidic soil that spreads in most areas by moderately acidic and strongly acidic conditions with soil pH from 4 to 6. |
| **Land cover & land use** | | Predominantly agricultural land |

## IC-2: Nangang River Basin, Taiwan



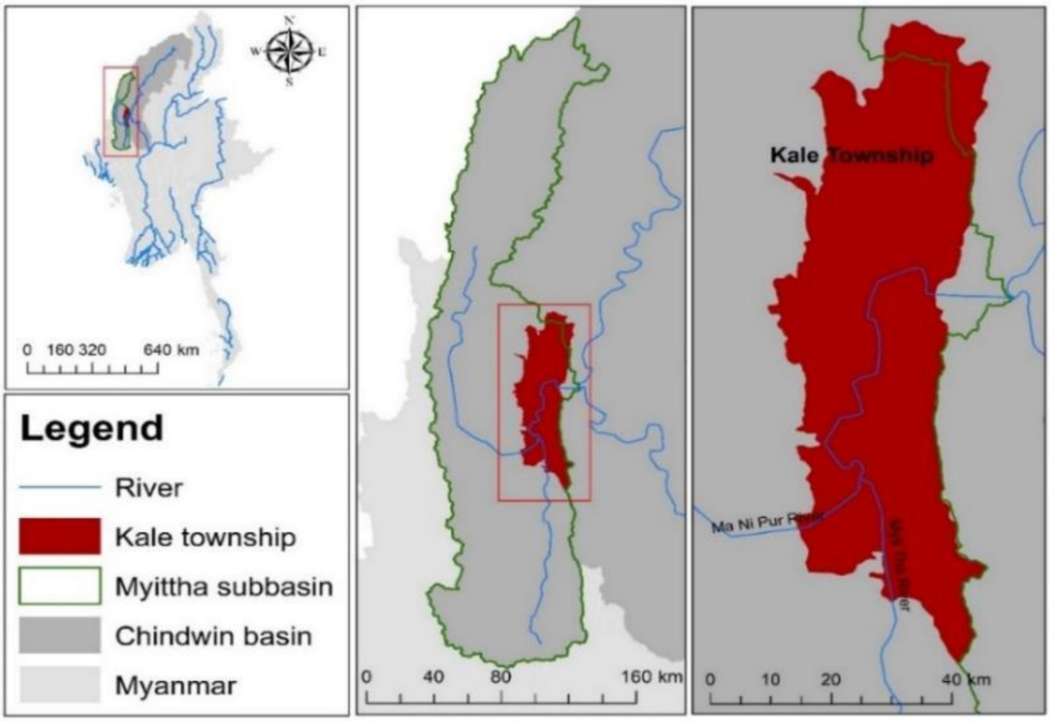

| | |
|---|---|
| **Climate** | Subtropical climate zone. Mean temperature for the area is 19.2 ℃. |
| **Terrain topography** | Mountainous with steep slope |
| **Soil & geology** | Mainly composed of Entisols, Alfisols, Ultisols and Oxisols under the Soil Taxonomy.<br>Faults in this region which create earthquakes. |
| **Land cover & land use** | Mainly non-urban land with large-scale forestry land, soil security land and agricultural land |

## IC-4: Cameron Highlands, Malaysia



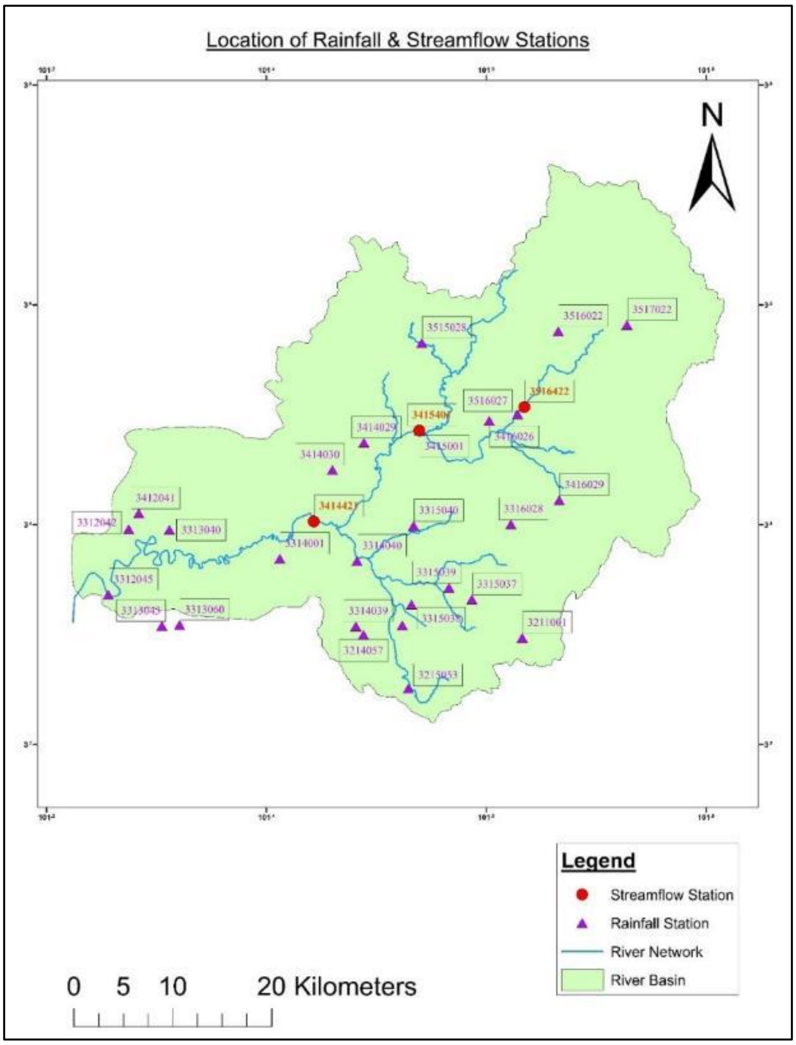

| | |
|---|---|
| **Climate** | Frequent precipitation. January and February are the driest months, October and November are the wettest months. |
| **Terrain topography** | Highlands are steep and highly dissected. The surrounding area is hilly to very steep. |
| **Soil & geology** | There are two soil types: soils of the Hills and Mountains (Steepland) |
| **Land cover & land use** | Predominantly agricultural land |

## IC-6: Myittha River Basin, Myanmar




| | |
|---|---|
| **Climate** | Tropical climate mean annual maximum and minimum temperature ranges from 16 to 31 °C |
| **Terrain topography** | The elevation of Myittha basin ranges from 91 m to up to more than 2500 m |
| **Soil & geology** | Mainly characterized by Paleogene sedimentary rocks |
| **Land cover & land use** | Dominated by forests cover in high elevation area with some agricultural land |

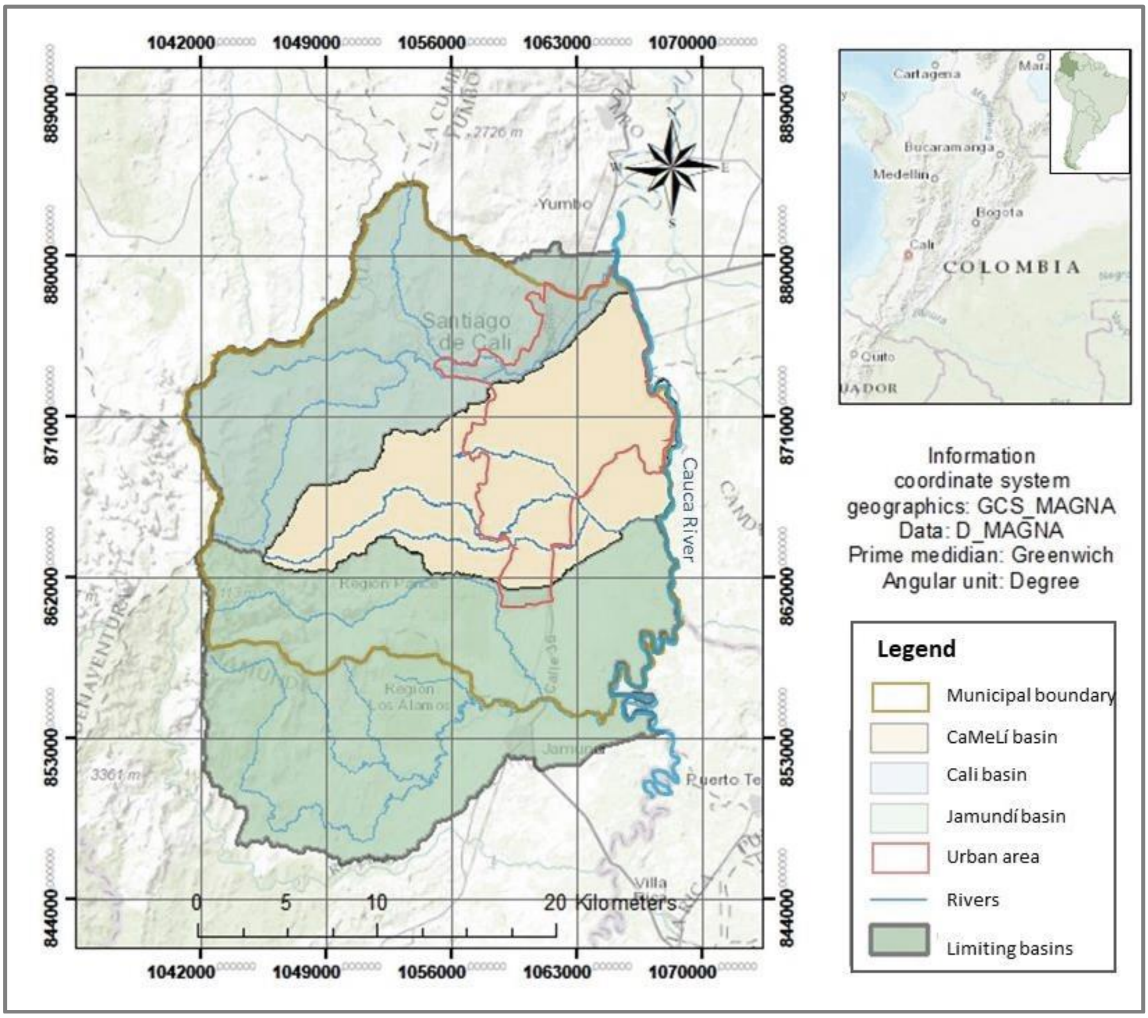
## IC-7: Sungai Selangor River Basin, Malaysia




| | |
|---|---|
| **Climate** | Relatively humid climate with slight variation in temperature throughout the year. The long-term average annual rainfall ranges from 2000 to 2500 mm. Two periods of extensive rainfall peaks are typically experienced during the transition period between the monsoons (April and November). |
| **Terrain topography** | Major part of the basin is below 300 m a.s.l., while the headwater part has steep slopes with up to 1800 m a.s.l. |
| **Soil & geology** | Few soil types are available, which are dominated by ex-mining land, peat, *keranji*, and agricultural soil for spinach farms. |
| **Land cover & land use** | Share of the developed area is 47 %, consisting of industrial, commercial, residential, mixed development recreational, utilities and infrastructures. The remaining 53 % consists of water bodies, reserved forest area, and bare land. |

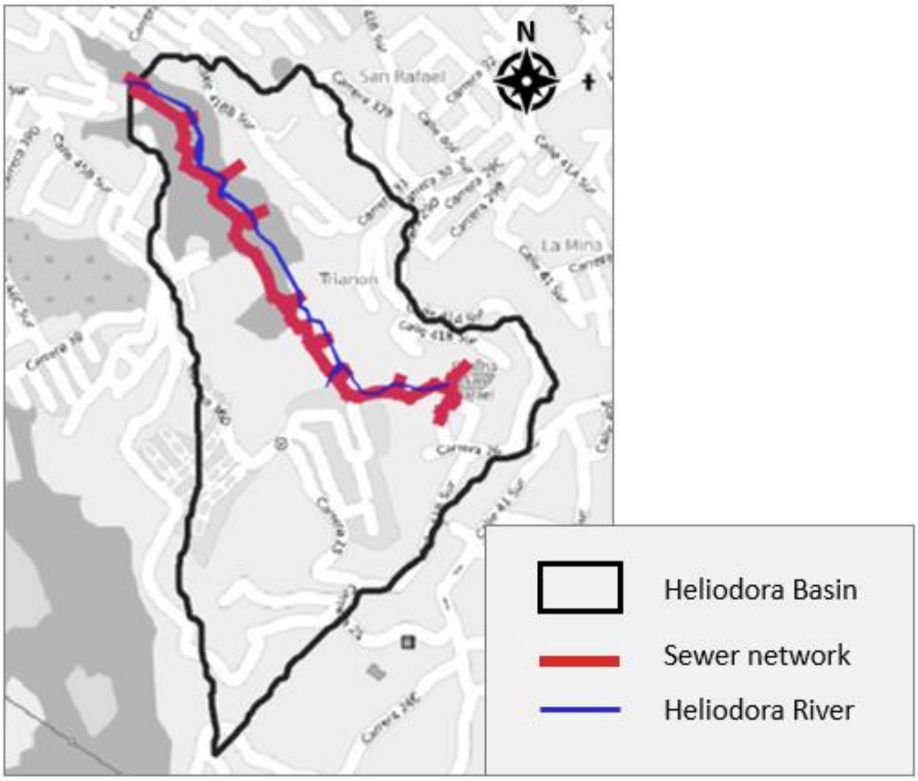
### 3.1.3 Colombian Collaborators

**IC-12: Cañaveralejo, Lili and Melendez River Basins, Cali, Colombia**




| | |
|---|---|
| **Climate** | The upper part of the basin registers the lowest temperature, with a minimum of 16°C and the lower part can reach a maximum of 31°C. |
| **Terrain topography** | Mountainous with elevations range above 2000 m, a foothill zone between 1200 m and 2000 m, and a flat zone below 1100 m |
| **Soil & geology** | Two large areas mainly Cretaceous volcanic rocks in the West and Quaternary deposits, which form a flat zone in the East. |
| **Land cover & land use** | 51.17% is urban territory and the remaining 48.83% is rural territory |

## IC-14: Heliodora Basin, Medellin, Colombia




| | |
|---|---|
| **Climate** | The average temperature in Envigado and Medellin is around 21.1 °C. |
| **Terrain topography** | The mean slope of the riverbed is 13%. Elevation in the basin varies from 1743 to 1565 meters above sea level. Riverbanks have steep slopes prone to landslides. |
| **Soil & geology** | The geological units exhibited in the study zone are: Anthropic Deposits, Alluvio - torrential deposits, Slip Deposits, Slope Deposits and Migmatites of Puente Peláez. |
| **Land cover & land use** | Forest fragments closely surrounded by urban infrastructure |

## 3.2 Summary of Collaborators' assessments

### *3.2.1 Hazards in Collaborator sites*

Floods are the most common hazards in all Collaborator sites, including fluvial, pluvial, and flash floods. Yet, in some Collaborator sites floods have caused more significant damages and impacts than in others. Figure 10 shows a summary of the types and number of events that have been recorded in each Collaborator for the past 15 years.

Besides floods, other hazards include droughts, landslides and forest fires, as well as the earthquakes. Landslides and their consequences (land instability and scour) are the second most recorded hazard in all sites. Forest fires and earthquakes are mentioned among Colombian Collaborators.

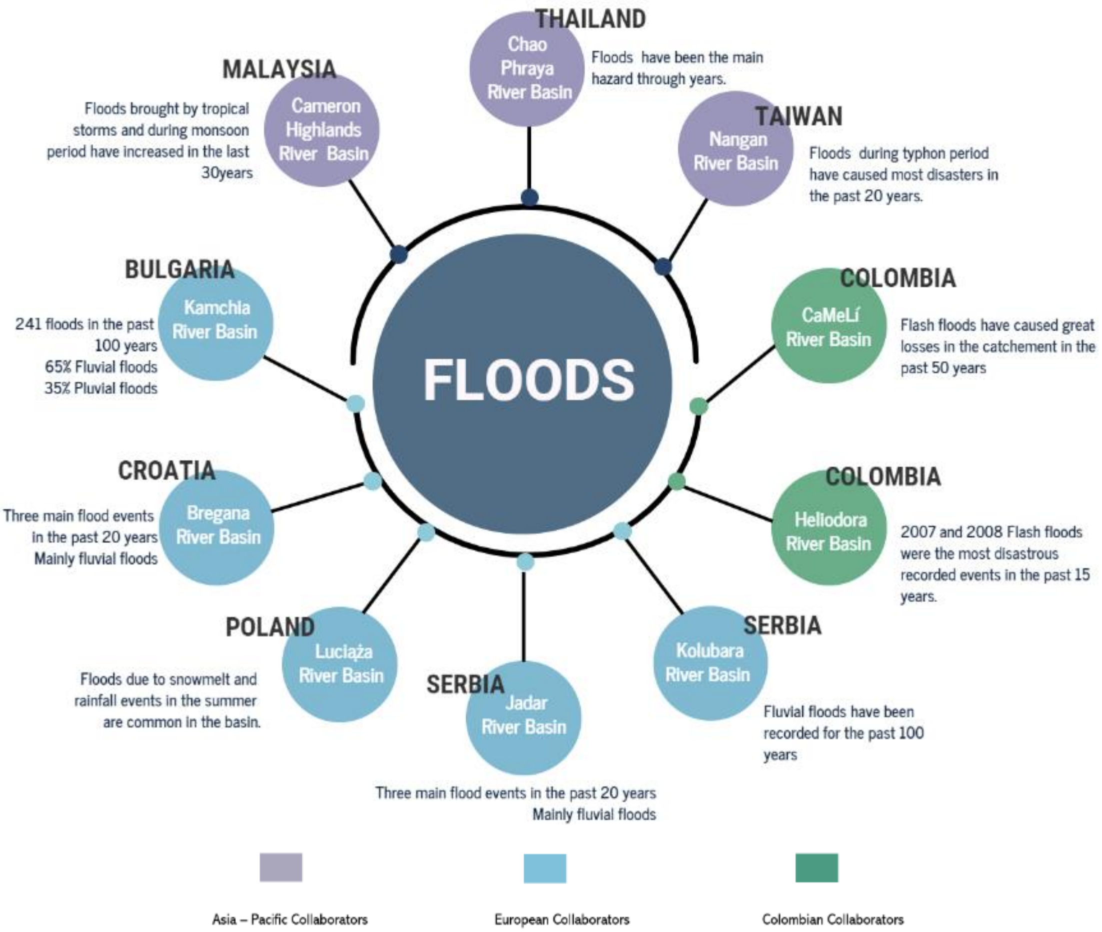



*Figure 10. Summary of hazard history in Collaborators sites.*

According to the EU Solidarity Fund, water-related hazards are the most frequent events triggering disasters in Europe. Statistics show that floods have caused most physical damages in European countries for the past 20 years (European Commission, 2020). However, while all European Collaborators are affected by at least one hydro-meteorological hazard, geophysical hazards such as landslides, and earthquakes have also increased in frequency and represent hazards that could trigger future risks in their basins. For example, Figure 11 shows that the Kolubara River Basin in Serbia is exposed to a wide range of hazards of different nature.

| | Floods | Droughts | Landslide | Heatwave | Earthquake |
|---|---|---|---|---|---|
| **BULGARIA** Kamchia River BAsin | ✓ | | | | |
| **CROATIA** Bregana River Basin | ✓ | | | | |
| **POLAND** Luciąża River Basin | ✓ | ✓ | | | |
| **SERBIA** Jadar River Basin | ✓ | | ✓ | | |
| **SERBIA** Kolubara River Basin | ✓ | ✓ | ✓ | ✓ | ✓ |

*Figure 11. Summary of current risks and hazard types in European Collaborators.*

Asia-Pacific Collaborators highlighted that hydrological, climatological, and geophysical hazards are the most common events triggering disasters within their site sites, with floods, droughts, and landslides causing most impacts in their regions. Figure 12 shows an overview of the hazards with the most potential to cause disasters in each site area.

The experiences among the Asia-Pacific Collaborators are indeed representative of the broader context. From the over 7,000 disaster events registered during the past 20 years in EM-DAT (Emergency Events Database), around 41% are placed in Asia. Asian countries are ranked as the most affected by floods and storms globally, and South East Asia is the region with most registered deaths due to these atmospheric events (CRED & UNDRR, 2020).

For Colombian Collaborators, hydro-meteorological hazards have caused disasters with most damages in their catchments (Figure 13). However, forest fires and earthquakes have been occurring more frequently than before, which is the reason why they consider these types of hazards as requiring more attention.

| | Floods | Droughts | Landslide | Heatwave | Earthquake |
|---|---|---|---|---|---|
| **TAIWAN** Nangang River Basin | ✓ | | | | |
| **THAILAND** Rangsit Community | ✓ | ✓ | | | |
| **MALAYSIA** Cameron Highland Basin | ✓ | | ✓ | | |
| **MYANMAR** Myittha River Basin | ✓ | ✓ | | | |

*Figure 12. Summary of current risks and hazard types in Asia-Pacific Collaborators*

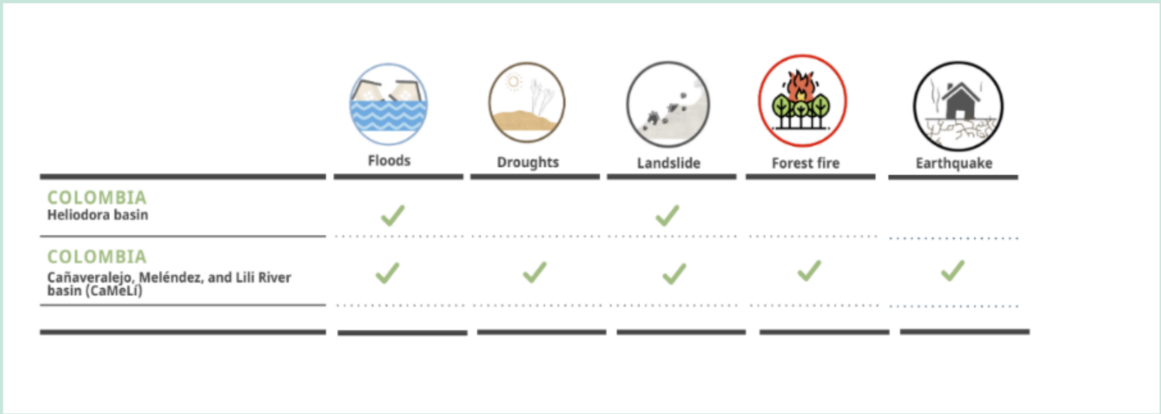



*Figure 13. Summary of current risks and hazard types in Colombian Collaborators.*

### *3.2.2 Physical characteristics of basins in Collaborator sites*

**Watersheds and drainage networks**. The figures below show basic information about catchments in Collaborators' cases: catchment areas, river lengths, and discharge. Most cases have smaller focus areas than the complete drainage areas of river catchments, and consequently the length of the river reaches within the focus area is smaller than the whole river length. Figure 16 shows that the maximum recorded discharges are mostly exceeding the average discharges by factors ranging from about 2 to about 70 (for the Serbian case of the Kolubara River).

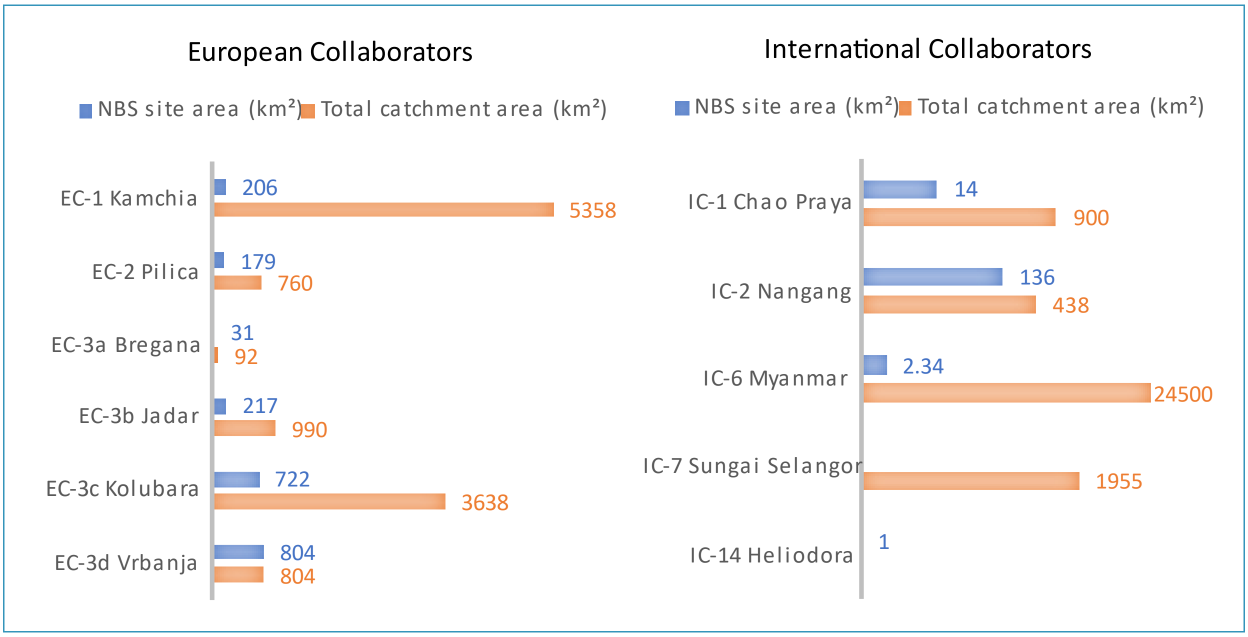



*Figure 14. Total catchment areas and NBS site areas in Collaborator cases.*

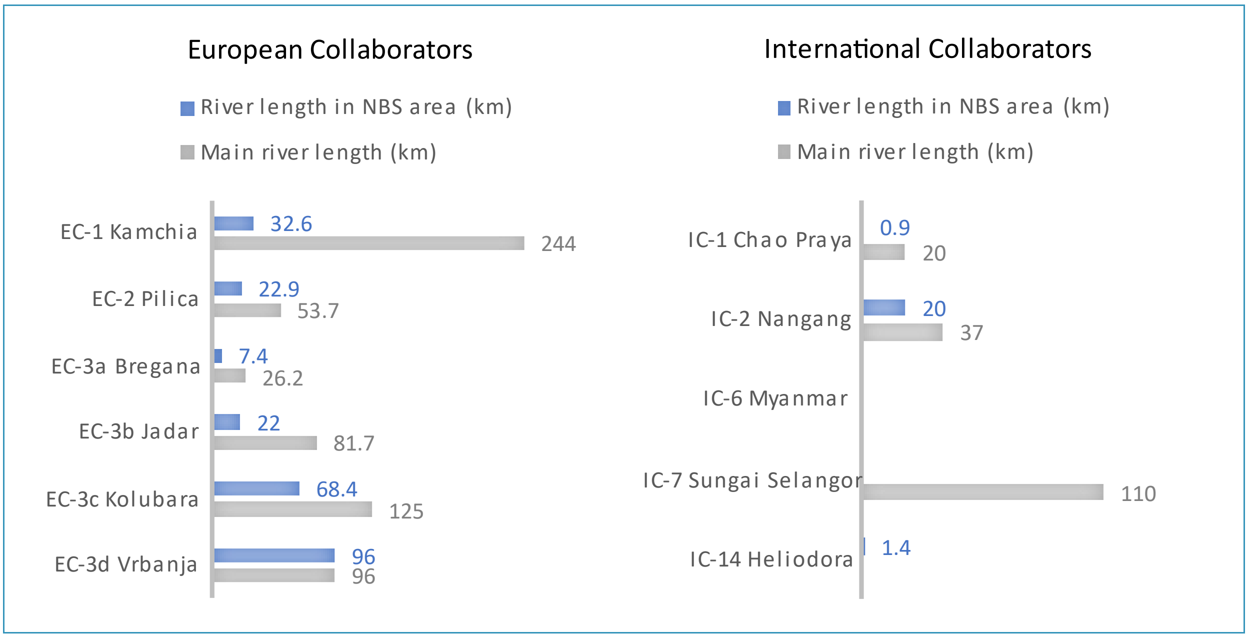



*Figure 15. River lengths in Collaborator cases.*

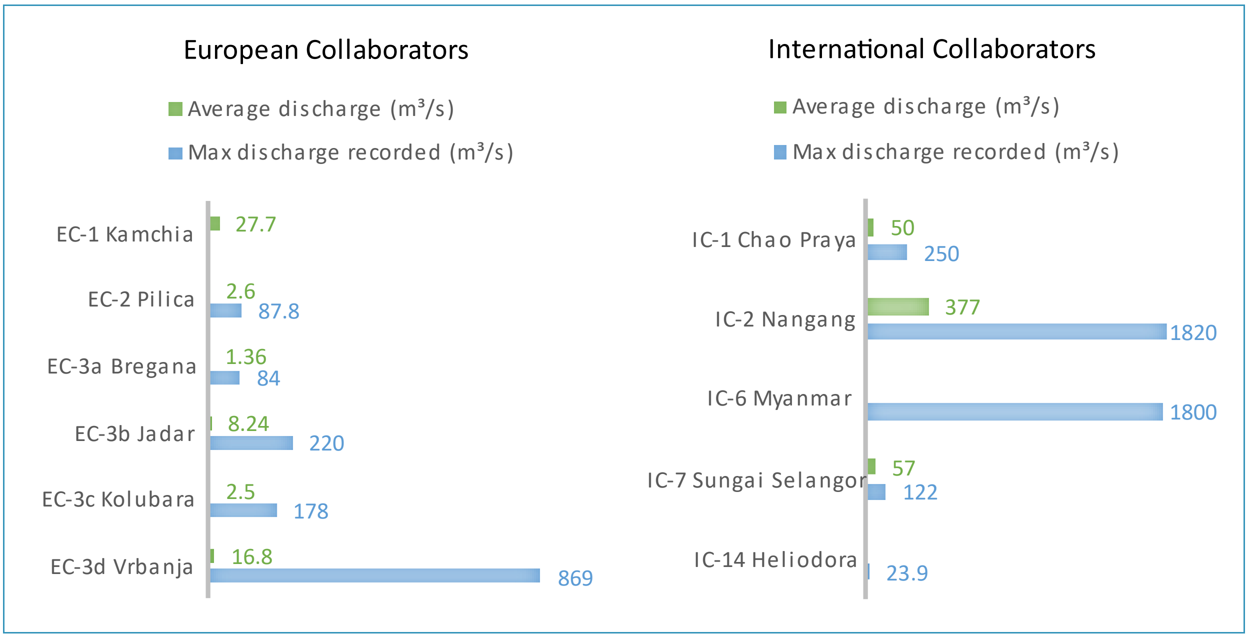



*Figure 16. Average and maximum discharges in main rivers in Collaborator cases.*

**Wetlands, lakes, ponds, marshes**. Surface water bodies, especially the ones composed by fresh water, play a big role in the water balance and ecology of a catchment. Wetlands provide several benefits to their surroundings such as groundwater recharge, flood mitigation, habitat provision to different species. Lakes and ponds represent good points for water collection and interception. When these elements are present in the catchment and well monitored, their sediments can function as early warning systems for predicting droughts (NOAA, 2017).

Artificial ponds are the most common superficial water bodies among Collaborators, followed by wetlands and reservoirs. Information provided also shows that four Collaborators sites have no surface water bodies inside their Basins (Nangang river basin, Myhitta river basin, CaMeLí river basin and Jadar river basin).

**Groundwater.** Aquifers are one of the most important natural resources on Earth. Together with the other freshwater bodies inside the catchment, groundwater represents a vital element of water available in the basin. However, information about the aquifer status and health seems to be limited or difficult to obtain in all Collaborators sites.

Groundwater quality is one of the areas in which European Collaborators have most information. Three of the five sites have monitoring stations and all of them have some knowledge on the water quality of the Aquifer. Asia-Pacific Collaborators, on the other hand, have limited or no information about the aquifer. Some of them even consider that groundwater information is not relevant in their site area. For the Colombian sites, only CaMeLí basin has information about their aquifer and they reported it to be in good condition. The tables below contain key information about the groundwater quality and availability in the different Collaborator´s sites.

*Table 6. Summary of key information on groundwater in European Collaborators*

| BULGARIA<br>Kamchia River Basin | CROATIA<br>Bregana River Basin | POLAND<br>Luciąża River Basin | SERBIA<br>Jadar River Basin | SERBIA<br>Kolubara River Basin |
|---|---|---|---|---|
| 12 monitoring station<br><br>High groundwater infiltration | 2 monitoring sites<br><br>Aquifer in good condition<br><br>No danger of groundwater pollution | Good groundwater quality<br><br>Aquifer is prone to chemical pollution | 13 monitoring stations in the aquifer, however, just one of them is located inside Jadar River Basin<br><br>There is a high risk of groundwater over extraction. | 5 monitoring stations inside Kolubara basin<br><br>Groundwater table at the outlet of the basin varies due to mining activities. |

*Table 7. Summary of key information on groundwater in Asia-Pacific Collaborators.*

| TAIWAN<br>Nangang River Basin | THAILAND<br>Chao Phraya River Basin | MALAYSIA<br>Cameron Highland Catchment | MYANMAR<br>Myittha River Basin |
|---|---|---|---|
| Groundwater information is not relevant for the case study | Shallow groundwater quality is not suitable for domestic use. However, the deeper groundwater (300-450 m) has a suitable quality. | No use of groundwater in the area | N/A |

*Table 8. Summary of key information on groundwater in Colombian Collaborators.*

| COLOMBIA<br>Heliodora River Basin | COLOMBIA<br>CaMeLí River Basin |
|---|---|
| Aquifer is in good condition | N/A |

### *3.2.3 Vulnerabilities*

Vulnerability is related to the characteristics and circumstances of a community (UNISDR, 2009); these characteristics and circumstances make a community susceptible to a hazard which can cause harm or loss. Various physical, social, economic, and environmental factors can determine the vulnerability of a community as well as the degree of susceptibly of the people in an area and the things that surround them. Four types of vulnerabilities are typically distinguished:

- Physical vulnerability is the potential for physical impacts on the man-made environment (e.g., buildings, their contents, transportation infrastructure, etc.).
- Economic vulnerability is the potential impact of hazards on economic assets and processes and the different economic sectors (e.g., production losses, losses due to closure of transportation routes, etc.)
- Social vulnerability is the potential impact of events on social groups (displacement of local population, threat to health and lives, threat to cultural heritage, etc.)
- Environmental vulnerability is the potential impact of events on the environment (flora, fauna, ecosystems, biodiversity).

Tables 9, 10 and 11 summarize the social, environmental, economic, and physical elements susceptible to hazard impacts in Collaborator sites.

The most common economic activity in all Collaborator sites is agriculture and thus it is identified in almost all cases as an activity at risk from hazards. Even though many of the cases are in rural or peri-urban areas, roads and highways have been identified as some of the most vulnerable physical infrastructure in all basins.

*Table 9. Overview of social, environmental, economic, and physical elements susceptible to hazard impacts in European Collaborators.*

| | SOCIAL | ENVIRONMENTAL | ECONOMIC | PHYSICAL |
|---|---|---|---|---|
| BULGARIA<br>Kamchia River Basin | Three municipalities- in the basin with a total of 32,693 inhabitants | Around 40% of the territory - Natura 2000 network,<br><br>No nature parks or protected areas in the focus area. | Economic activities are agriculture, industrial water supply and irrigation, timber industry, stock breeding, food industry and tourism. | Main road<br>Several secondary and third-class roads<br>Hydropower plants<br>Wastewater treatment plants |
| CROATIA<br>Bregana River Basin | A total of 4303 inhabitants in the basin | Upstream - NATURA2000<br>Downstream - HR2001506-Sava. | Dominant economic activity is agriculture. | Border crossings, roads, and motorways<br>Schools<br>Small industries<br>Bridges. |
| POLAND<br>Luciąża River Basin | The population of the focus area is about 115,000 inhabitants. | Protected natural areas are primarily forests and river valleys | Dominant economic activity is agriculture. | Low density of buildings and transport network |
| SERBIA<br>Jadar River Basin | Three main municipalities in the basin with total of 102,001 inhabitants. | Eco-region 11 | Dominant economic activity is agriculture | Transport infrastructure (roads and railways), power infrastructure (power transmission network power distribution network)<br>Water supply infrastructure |
| SERBIA<br>Kolubara River Basin | Total population in the basin is 219,928 inhabitants (49,268 inhabitants are vulnerable to flood hazards) | Protected natural areas are primarily forests and river valleys, while the focus area – Tamnava river basin has no protected areas. | Dominant economic activity is agriculture | Transport infrastructure (roads and railways)<br>Water management infrastructure<br>Energy infrastructure |

Social vulnerability has been approached by Collaborators as the number of inhabitants in the area that could be affected by the hazard. In European Collaborators the population that could be affected by the hazard ranges between 10,000 and 50,000 people, while in Asia-Pacific Collaborators the populations are smaller but highly exposed to the hazard.

*Table 10. Overview of social, environmental, economic, and physical elements susceptible to hazard impacts in Asian Collaborators.*

| | SOCIAL | ENVIRONMENTAL | ECONOMIC | PHYSICAL |
|---|---|---|---|---|
| TAIWAN<br>Nangang River Basin | Puli Township has an estimated population of 83,021 inhabitants. | There are 1.6 km^2 aquatic ecosystem in the focus area. | Main economic activity is agriculture | Several roads and bridges that have been affected by previous floods. |
| THAILAND<br>Chao Phraya River Basin | The total population in the focus area is 51,252 inhabitants. | N/A | The main economic activity is agriculture | Mainly irrigation infrastructure with some populated areas with a university nearby and several roads. |
| MALAYSIA<br>Cameron Highlands Catchment | There is a total population of 34,510 inhabitants in Cameron Highlands. | N/A | The three main economic activities are tourism, hydropower, and agriculture | The main physical infrastructure is the Sultan Abu Bakar Dam. |
| MYANMAR<br>Myitta River Basin | N/A | N/A | Food process industry and agriculture | Houses, bridges, roads, wells, buildings, public infrastructure and agriculture lands |

*Table 11. Overview of social, environmental, economic, and physical elements susceptible to hazard impacts in Colombian Collaborators.*

| | SOCIAL | ENVIRONMENTAL | ECONOMIC | PHYSICAL |
|---|---|---|---|---|
| COLOMBIA<br>Heliodora Basin | N/A | N/A | More information is needed | Sewer network is in the margins of the basin |
| COLOMBIA<br>CaMeLí Basin | Rural area extends to 43,718 hectares where 36,738 people live. | N/A | Main economic activities are agroindustry, agriculture, and tourism | N/A |

### 3.2.4 *Measures for risk management*

Since the floods are the hazard which has caused the strongest impact among all Collaborator cases, Baseline Assessment for each Collaborator provides a list of the existing and planned measures for flood risk management that can be found inside their basins. These include both structural measures (physical construction to reduce or avoid the impacts of a hazard, such as dikes, dams, channels etc.) and non-structural measures (those not involving any physical infrastructure; e.g., early warning systems, operational rules for reservoirs, regulation on land use, awareness raising, etc.).

The most common structural flood mitigation measures among Collaborator sites are dikes or river embankments and built canals or ditches, as well as bank stabilisation (Table 12). Storage for floods in form of retention and detention ponds, as well as multi-purpose reservoirs, is the most frequent planned measure. This may potentially indicate that the existing measures such as bank stabilisation or dikes are being currently recognised as insufficient for effective mitigation of floods, leading to the need for flood water storage and more efficient reduction of flood peaks and volumes.

*Table 12. Existing and planned structural measures for flood mitigation in Collaborators sites.*

| Structural measures | European Collaborators | | | | | | International Collaborators | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EC-1 | EC-2 | EC-3a | EC-3b | EC-3c | EC-3d | IC-1 | IC-2 | IC-4 | IC-7 | IC-12 | IC-14 |
| Embankments / dikes / levees | +o | | + | + | +o | + | | +o | | | | |
| Flood water gates | + | | | | | | + | | | | | |
| Channels / drainage ditches | + | | | | + | | + | | +o | | | |
| Ground sills | + | | + | + | | | | | | | | |
| Deepening / widening of riverbed | o | | | | + | | | | | o | | |
| Wetland restoration | o | | | | | | | | | | + | |
| Afforestation / reforestation | o | o | | o | +o | | | | | | + | |
| Reservoirs | | + | | | o | o | | | | + | | |
| Retention / detention ponds | | o | o | +o | o | | | | | +o | | |
| Restoration of (oxbow) lakes | | o | | | | | | | | | | |
| Irrigation (drought control) | | o | | | | | | | | | | |
| Bank stabilisation | | | | +o | +o | +o | | + | | o | | |
| Erosion control / check dams, sediment barriers | | | | +o | | o | | | | | | |
| Removing obstacles (reconstruction of bridges) | | | | | | + | | | | | | |
| Soil restoration | | | | | | | + | | | | | |
| Rainwater harvesting | | | | | | | | | + | | | |
| Deepening or dredging of reservoirs | | | | | | | | | o | | | |
| Sewer lines | | | | | | | | | | | + | +o |

Legend: + Existing o Planned

*Table 13. Existing and planned non-structural measures for flood mitigation in Collaborators sites.*

| Non-structural measures | European Collaborators | | | | | | International Collaborators | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **EC-1** | **EC-2** | **EC-3a** | **EC-3b** | **EC-3c** | **EC-3d** | **IC-1** | **IC-2** | **IC-4** | **IC-7** | **IC-12** | **IC-14** |
| Monitoring / installation of sensors | o | | | | + | | + o | | | | | + |
| Flood forecasting / early warning systems | | | + | | o | | | | | | | o |
| Installation of cameras for monitoring | | | | | | | o | | | | | |
| Reservoir water level control | | | | | | | | | + o | | | |
| Crop management | | | | | | | | | + | | | |
| Soil management | | | | | | | | | + | | | |
| Stakeholder capacity building | | | | | | | | | o | | o | |
| Water resources management | | | | | | | | | | | o | |
| Land use management | | | | | | | | | | | o | + |
| Environmental management | | | | | | | | | | | o | |
| Legend: + Existing o Planned | | | | | | | | | | | | |

Collaborators generally reported on very few non-structural measures in their sites (Table 13). Malaysian site IC-4 (Cameron Highlands) reported the most existing non-structural measures, including several reservoir operational rules, crop management (e.g., crop rotation) and soil management (improving soil structure to enhance erosion resilience). Colombian site IC-12 (Cali) reported a range of planned non-structural measures, emphasizing the need for an integrated approach in management of water resources, land use and environment.

The measures that can be classified as NBS are already being planned in some Collaborators. This is especially true for retention ponds, which are planned at several sites, as well as the measures for erosion control (mostly afforestation and reforestation, followed by works such as check dams or sediment barriers). Also, the need for soil management, especially management of agricultural land and improvement of agricultural practices, is recognised.

### *3.2.5 Political and regulatory context (incl. relevant policies)*

Policies and regulations are highly decisive for creating, enabling or obstructing conditions for implementation of NBS (Nesshöver, et al., 2017). NBS therefore need to be embedded in the existing policy mix covering biodiversity protection measures, spatial planning, environmental assessment, or economic incentives. Though an abundance of information about NBS sites is already available (Debele et al., 2019), there remains a need for integrating NBS into policy guidelines.

Internationally, the Sendai Framework, as the global policy guiding disaster risk reduction (DRR), recognizes and promotes the role of NBS in achieving risk reduction (UNDRR, 2021). Other international frameworks include the Paris Agreement on Climate Change, the Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda, the UN Sustainability Framework, the Global Framework for Climate Services, the United Nations Framework Convention on Climate Change, and ultimately the Sustainable Development Goals. However, as Table 14 shows, these frameworks are not contemplated by RECONECT

Collaborators amongst the array of plausible international policies. Though further research is needed to assess the reasons behind this, it is likely that the results from RECONECT Collaborators reflect the general difficulty to harmonize horizontally across international DRR and adaptation agendas, as well as vertically between international agendas and national policies (Islam, et al., 2020a; Islam et al., 2020b; Seidler et al., 2018). The European Collaborators refer only broadly to EU Directives, examples of which include the Water Directive or the Floods Directive. However, multiple EU policies have played an important role in advancing implementation of NBS as the first line of defence against hazards in different climatic conditions and regions (Kumar et al., 2020).

Most knowledge on policies amongst the Collaborators from all regions is at the national level. In the case of the European Collaborators, information was also provided at the level of regions. There is very little information on the local level. Further research is needed to assess whether this is due to centralized governance systems – whereby regulations are primarily set at the national level – or whether this is rather reflecting an information gap amongst our Collaborators.

*Table 14. Multi-level policies ruling the implementation of NBS in European Collaborators.*

| EUROPEAN COLLABORATORS | | | | |
|---|---|---|---|---|
| **Collaborator** | **International level** | **National level** | **Regional level** | **Local level** |
| **EC-1 Bilgaria** | | Water Act; National Funds under the Disaster Protection Act | Water Act; Basin Directorates; Fund Plans managed by the Interdepartmental Commission | Municipal Budget Funds for Disaster Protection Activities |
| **EC-2 Poland** | N/A | Management Plan for Vistula River Basin; Flood Risk Management Plan for Vistula River Basin; Drought Effects Counteracting Plan | Regional Spatial Development Plans; Voivodeship Development Strategy | Environmental protection programs for commune; Spatial Development Plans for commune |
| **EC-3a Croatia** | EU Directives | Water management strategy; Croatian Water Law; Water Management Financing Act; Flood Risk Management Plan; Multiannual program for the construction of regulatory and protective water and reclamation facilities | N/A | N/A |
| **EC-3b Serbia** | EU Directives | Water Management Strategy; National Spatial Plan; Serbian Water Law | Flood Risk Management Plan for the Sava River Basin; Regional Spatial Plans | N/A |
| **EC-3c Serbia** | EU Directives | Water Management strategy; Serbian Water Law; Flood Risk Management Plan; Sectoral strategies | Regional Spatial Plans | N/A |

*Table 15. Multi-level policies ruling the implementation of NBS in Asian Collaborators.*

| ASIAN COLLABORATORS | | | | |
|---|---|---|---|---|
| **Collaborator** | **International level** | **National level** | **Regional level** | **Local level** |
| **IC-1 Thailand** | N/A | National Development plan “Green Growth”; Natural Resources and Environment Reform | N/A | N/A |
| **IC-2 Taiwan** | N/A | Infrastructure Development Program | N/A | N/A |
| **IC-4 Malaysia** | N/A | National Disaster and Relief Management Policy | N/A | N/A |
| **IC-6 Myanmar** | N/A | N/A | N/A | N/A |

*Table 16. Multi-level policies ruling the implementation of NBS in Colombian Collaborators*

| COLOMBIAN COLLABORATORS | | | | |
|---|---|---|---|---|
| **Collaborator** | **International level** | **National level** | **Regional level** | **Local level** |
| **IC-12 Cali** | N/A | Urban Environmental Management Policy; Integral Management of Water Resources Policy; Integrated Management of Biodiversity and Ecosystem Services Policy; Sustainable Soil Management; National Climate Change Policy | N/A | N/A |
| **IC-14 Medellin** | N/A | Territorial Order Plan (POT); Sanitation Plan; Wastewater Discharge Law; | N/A | Heliodora Environmental Park Declaratory Act |

# 4 Potential for NBS in Collaborator sites

Analysis of potential measures for risk reduction makes the second important part of the baseline assessments for the Collaborator sites and the necessary step towards the development of pre-feasibility studies for implementation of NBS in the Collaborators' focus areas.

The RECONECT methodology for selecting potential measures is described in section 2.4, and comprises two steps:

1) preliminary selection of measures from the RECONECT catalogue of measures, and
2) ranking of the short-listed measures using a multicriteria analysis (MCA) framework with incorporated stakeholders' opinions on the importance of the impacts that selected NBS provide.

This section describes the application of this methodology to Collaborator sites and discusses some of the results.

## 4.1 Preliminary selection of measures

Screening of measures from the RECONECT catalogue of measures was performed by using the Measure Selection Tool, developed within RECONECT.

The first screening of potential measures is made from the catalogue of measures by applying six filters, i.e., criteria on the types of measures to be applied, hazards, affected area, location for measures, project, and land use (see Figure 8). Table 17 shows the choice of criteria for each Collaborator site.

*Table 17. Collaborators' choice of criteria in preliminary selection of measures.*

| Criteria | | EC1 | EC2 | EC3 a | EC3 b | EC3 c | EC3 d | IC1 | IC2 | IC4 | IC12 | IC14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type of measure | Nature based solution | • | • | • | • | • | • | • | • | • | • | • |
| | Grey infrastructure | | | | | | | | | • | | |
| Hazard type | Riverine floods (fluvial floods) | • | • | • | | • | • | • | • | • | • | |
| | Pluvial floods | • | | | | | | | | • | • | |
| | Flash floods | • | | | • | • | • | • | | • | • | • |
| | Landslides | | | | • | • | • | | | • | | • |
| | Droughts | | • | | | | | • | | | | |
| Affected area | Urban area | • | | • | | | | | | • | • | • |
| | Non-urban area | • | • | • | • | • | • | • | • | • | • | • |
| Location of measures | Urban area | | | | | | | | | | • | |
| | Non-urban area: Mountainous area | | | | | | | | | | | |
| | Non-urban area: Coastal area | | | | | | | | | | | |
| | Non-urban area: River basin: Upper course | | | • | • | • | • | • | | • | | • |
| | Non-urban area: River basin: Middle course | • | • | • | • | • | • | | • | • | • | • |
| | Non-urban area: River basin: Lower course | • | | | | | | | | | | |
| Project type | Implementation of new measures | • | • | • | • | • | • | • | | • | • | • |
| | Improvement or expansion of existing measures | • | • | • | • | • | • | | • | • | • | • |
| Land use type | Artificial surface | • | | • | | | | | | | • | |
| | Agricultural areas | • | • | • | • | • | • | • | • | • | | |
| | Forrest and semi-natural areas | • | | • | • | • | • | | | • | • | • |
| | Wetlands | | | | | | | | | | • | |
| | Water bodies | • | | | | | | | • | • | | |

| Measures | Short description | Benefits | Suitability | Remark |
|---|---|---|---|---|
| 1. Afforestation, forests and naturally vegetated land | Afforestation is the process of planting trees, or sowing seeds, in areas that have ever been forested to create a forest. | Forests and areas with good vegetation cover can moderate extreme events by reducing the likelihood (or frequency) of floods, landslides, mudflows and avalanches, which can cause extensive damage to infrastructure and inhabited areas. | - | Not suitable because the Bregana area is already well forested. |
| 2. Reforestation and forest conservation | Reforestation is the restoration of forests in areas where forests were removed or destroyed | Trees and other plants also enrich the soil and increase its quality, they prevent the process of soil erosion and landslide also provide better water-retention. | - | Not suitable because the Bregana area is already well forested. |
| 3. Upper watershed restoration | Watershed restoration often uses bio-engineering techniques. Bio-engineering combines living plants with dead plants or non-living material to produce a living system that resists erosion. | Revegetation can be used in conjunction with soil erosion and slope stabilisation solutions, such as terracing and erosion barriers, especially in hilly areas. | X | Suitable, because on the upstream part of the basin there is a steep slope and erosion occurs, so small wicker dams are suitable but insufficient as a stand-alone solution. |
| 4. Buffer strips | Riparian buffers are treed areas alongside streams and other water bodies. | Riparian forest buffers can have greater water holding capacity than cutover or non-forest covered areas. | - | It is not suitable, because vegetation is already present along the shores, at least in most of it. |
| 5. Widening of water bodies | The river width is an activity which aim to increase the conveyances characteristics of river though widening by excavating the embankment. | This will increase the velocity of the river and reduce the chances of it flooding in the immediate area by moving the floodwater further on downstream. | - | It is not suitable, because the flood water cannot move downstream, because the downstream areas are also endangered, and often under the slowdown of the Sava River. |
| 6. Deepening water bodies | The water body bed is deepened by excavating the surface layer of the river bed. | The deepened water body's bed provides more room for the water. Increasing the depth of water bodies is also increasing the storage volume. | X | Suitable, although the Environmental Protection Agency does not approve this measure due to the protection of endangered fish species |

*Figure 17. An example of second screening of measures: checking suitability of the measures from the first screening (Bregana case, EC-3a).*

In the second screening, Collaborator partners reviewed their respective lists of preliminary measures using their expert knowledge to possibly identify the measures that were not relevant or not suitable for their site. Figure 17 shows an example for the second screening of measures for the Bregana case (EC-3a).

All Collaborators reduced the number of measures from the first screening, ranging from 6 to 22 (Figure 18). The reduced list of measures for several Collaborators still had a significant number of measures after the second screening. In these cases, the ranking of measures is obviously necessary to additionally reduce the number of measures and develop a prefeasibility study with a reasonable number of alternatives.

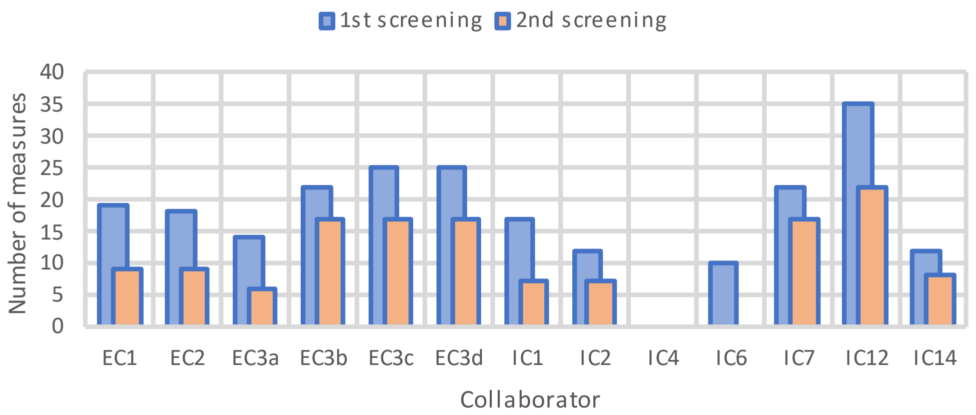



*Figure 18. Number of measures selected for Collaborator cases in the first and second screening of measures.*

## 4.2 Ranking of measures by MCA

Applying MCA for ranking of the selected measures for each Collaborator site included two main activities: conducting the stakeholder surveys and using the obtained results in the MCA framework. The questionnaire for the stakeholder survey was prepared (Annex A) in which the stakeholders were asked to choose weight from 0 to 10 for each goal/subgoal and also provide their comments. A template for the analysis of the survey results and further analysis of the measures was prepared in MS Excel. Each Collaborator entered the results of their stakeholder surveys into the Excel file, analysed the stakeholder preferences on benefits and co-benefits of NBS, and obtained the ranked list of measures.

### *4.2.1 Goals and subgoals weighting: stakeholder surveys*

Weighting the goals and subgoals of NBS through stakeholder participation is one of the main elements of the MCA framework for ranking of the measures selected in the preliminary screening (see section 2.4.2). This step was initially envisaged to be carried out through participatory workshops in each of the sites. However, due to Covid-19 the study was redesigned to collect stakeholders' perceptions through an online survey. The stakeholders' preferences questionnaire was implemented in Google Forms and then translated into local languages by the Collaborator partners to make it easier for the respondents to provide adequate responses. The survey was thereafter distributed by each Collaborator to their respective stakeholders that were previously identified within the stakeholder mapping activities in Collaborators (D4.1). At this stage of the project, it was decided that Collaborators would mainly reach out to local authorities, NGO/civil society, political representatives, and academia. Additionally, all Collaborator partners were also asked to provide responses to the survey, since they can also be considered as stakeholders for their sites.

The results of the stakeholder survey are comprised of the weights (score) ranging from 0 to 10 for each goal and subgoal entered by each stakeholder. Stakeholder groups are also noted so that the stakeholders' preferences can be analysed in this context as well (Figure 19 shows the number and distribution of responses across stakeholder groups). After entering the survey data into the prepared Excel template, tables and graphs showing the distributions of weights for all goals/subgoals are automatically updated.

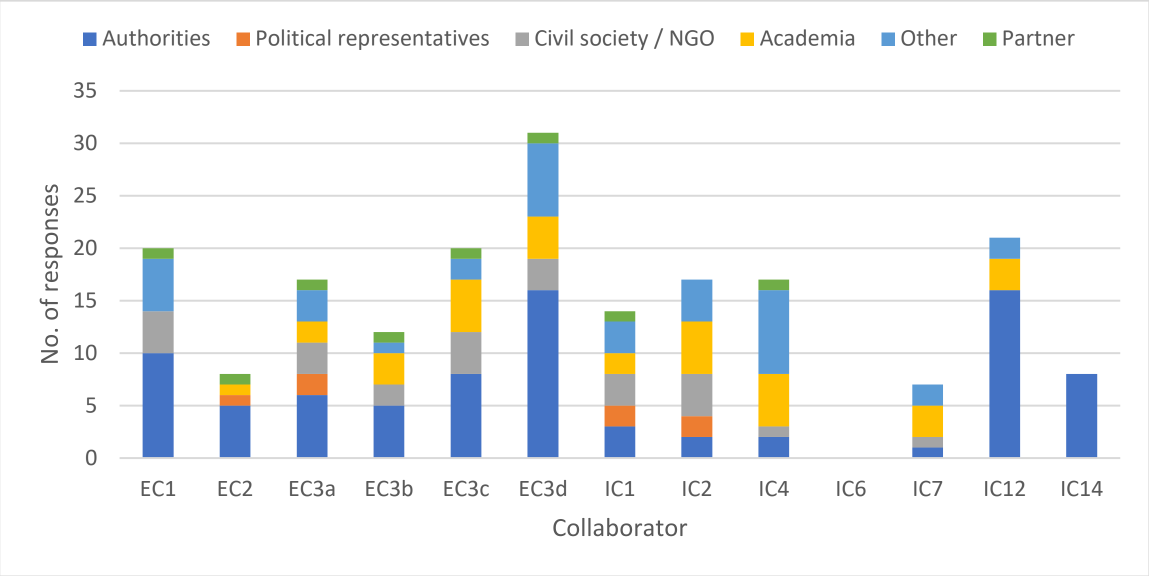



*Figure 19. Number of responses from stakeholders for the ranking of measures.*

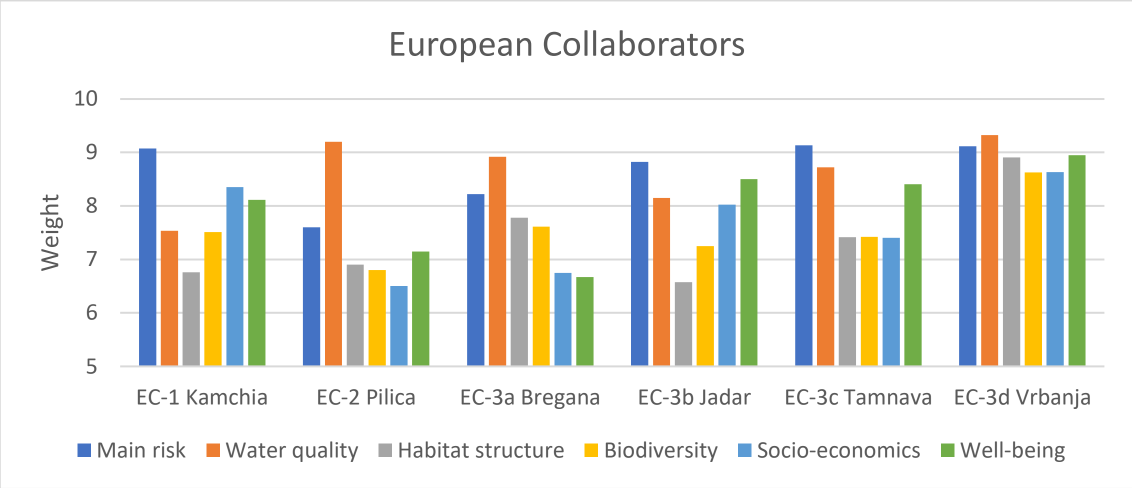



*Figure 20. Stakeholder weights for main goals – European Collaborators.*

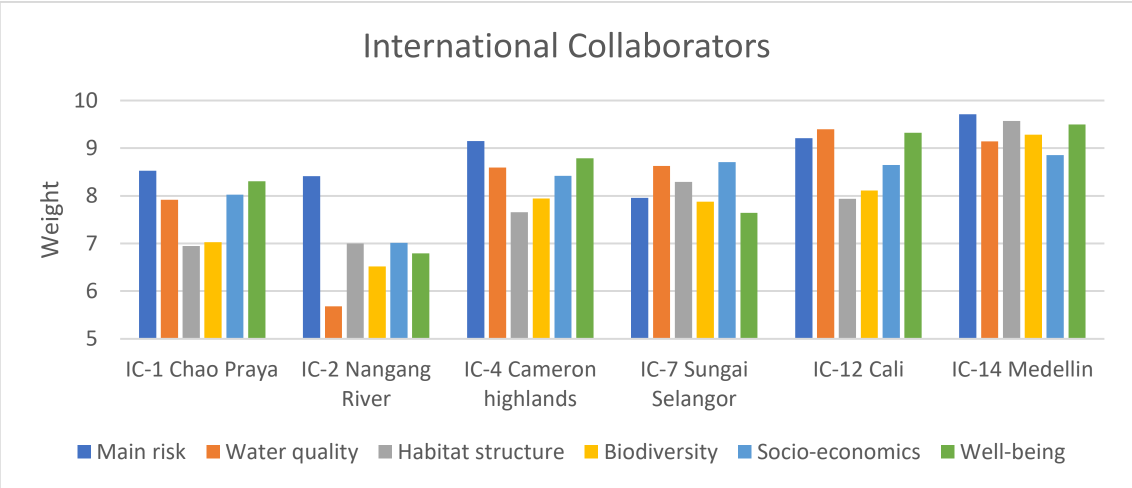



*Figure 21. Stakeholder weights for main goals – International Collaborators.*

The weights for the six main goals for each Collaborator are shown in Figures 20 and 21. On average, the weights for the goal of main risk reduction (typically floods) are high (above 8 for all but one Collaborator). This is the most important goal for 7 out of 12 Collaborators, while the Water Quality goal is the most important goal in 4 Collaborator cases. The least important goal cannot be singled out: Habitat Structure is the least important goal in 5 out of 12 cases, and Socio-economic goal in 3 out of 12 cases. Although there are differences among the individual Collaborators for each category of goals and considerable variability in individual stakeholder responses, on average there are no notable regional differences between weights of the European and International Collaborators (Figure 22). This indicates that the differences in stakeholders' opinion on a particular goal are more site-specific than region-specific and that they most likely originate from different stakeholder backgrounds. Figure 23 shows the average weights for main goals broken down by stakeholder groups for all Collaborator sites. It should be noted that most responders belong to the Authority stakeholder group, especially in European Collaborators, while the political representatives are the least represented group among all the stakeholders. Nevertheless, Figure 23 reveals a surprising bias toward the main risk goal and very low weights for the nature-related goals (biodiversity and habitat structure) by the Collaborator partners. Disappointingly, the nature-related goals are also valued relatively low by the authorities and political representatives, which are expected to provide support for such goals on the policy level. This figure also indicates lack of preferences for any particular goal among Civil Society and Academia that generally shows that these two groups appreciate the holistic view on the main risk reduction.

Since there is a significant variation in responses by the stakeholders across individual Collaborators and among individual stakeholders, making general conclusions from this data seems like an unrewarding task. Within RECONECT, other tasks (more specifically, Task 4.5 – Acceptability and feasibility of NBS and Task 4.6 – Analysis of barriers) may shed more light on the reasons behind certain biases in stakeholders' opinions.

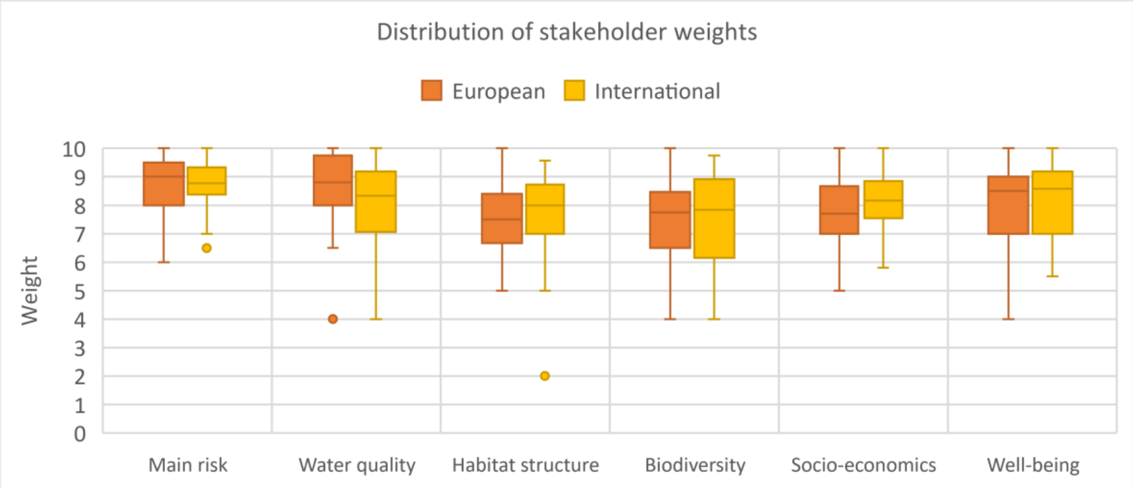



*Figure 22. Distributions of stakeholder weights for main goals across European and International Collaborators.*

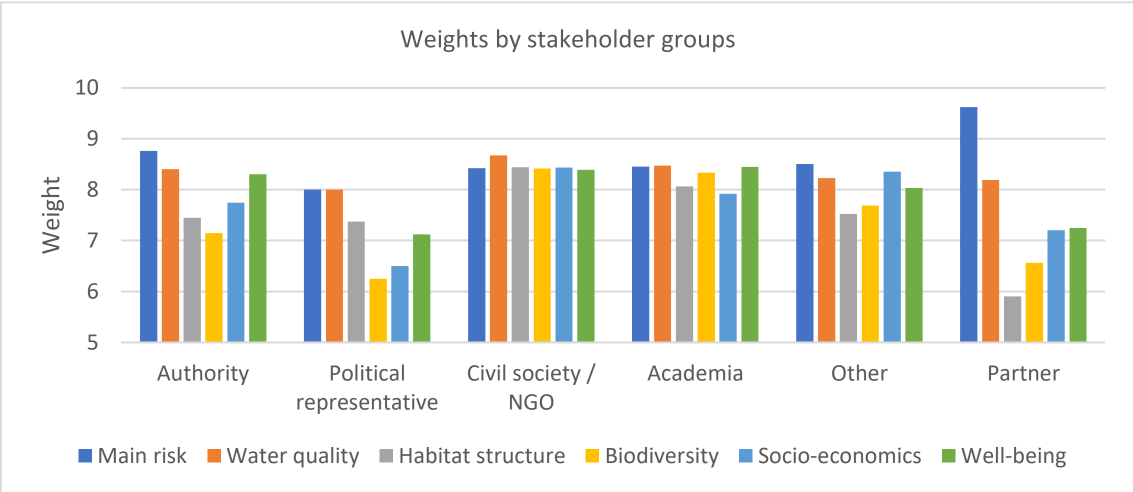



*Figure 23. Average weights for main goals by stakeholder groups.*

### *4.2.1 Ranking of measures*

Performance of each measure against the hazards is described by its final score, obtained as a weighted sum of the measure performance scores in achieving certain goals and subgoals. The final score is obtained for all hazards combined, but also for each particular hazard. Here, all types of floods (fluvial, pluvial and flash floods) are treated as the same hazard. The floods are the common hazard for all Collaborators (Table 18) and are accompanied by landslides in five Collaborator cases. Floods and droughts are a combined hazard in two Collaborator cases. Based on the final scores for all or particular hazards, the measures are ranked in the context of all hazards and separately for flood, landslides and droughts. Table 19 shows a joint list of top five measures for the Collaborators with the same combination of hazards (floods, floods and landslides, and floods and droughts).

*Table 18. Overview of main hazards in Collaborator sites.*

| Hazard type | EC1 | EC2 | EC3 a | EC3 b | EC3 c | EC3 d | IC1 | IC2 | IC4 | IC7 | IC12 | IC14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Floods | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Landslides | | | | ● | ● | ● | | | ● | | | ● |
| Droughts | | ● | | | | | ● | | | | | |

*Table 19. List of top five ranked measures in all Collaborator sites for three hazard combinations.*

| Top ranked measures | | |
|---|---|---|
| **Floods** | **Floods and landslides** | **Floods and droughts** |
| Urban trees/parks | Reforestation and forest conservation | Floodplain excavation/enlargement/restoration |
| Floodplain excavation/enlargement/restoration | Afforestation, forests and naturally vegetated land | Wetland restoration/enhancement |
| Upper watershed restoration | Detention basins | Bypass/diversion channels |
| Afforestation, forests and naturally vegetated land | Floodplain excavation/enlargement/restoration | Reconnection of oxbow lakes and remeandering |
| Wetland restoration/enhancement | Deepening water bodies | Retention ponds |
| Buffer strips | Wetland restoration/enhancement | Detention basins |
| Reforestation and forest conservation | Upper watershed restoration | Sand dam |
| Retention ponds | Live/rock check dams | Buffer strips |
| Natural bank stabilisation | Bypass/diversion channels | Natural bank stabilisation |
| Reconnection of oxbow lakes and remeandering | Lake restoration | |
| Detention basins | Vegetated slope techniques | |
| Rain gardens / Bio-retention area | | |
| Widening of water bodies | | |
| Bypass/diversion channels | | |
| Deepening water bodies | | |
| Dike relocation | | |
| Intensive green roofs | | |
| Lake restoration | | |

The ranking of measures related to all hazards in each Collaborator site is shown in Annex B, while Figure 24 presents an example for one of the Collaborators. The graph in the figure also shows partial scores of each measure related to six main goals, which combines performance score of the measure with the stakeholder weight for the particular sub-goal and goal. It can be seen that the partial score for the flood risk reduction is comparatively lower than the partial score for other goals, i.e., benefits and co-benefits. This demonstrates that it is important to include both main benefit and co-benefits into an analysis so that communities and ecosystems can benefit from selected NBS measure. If the measures in Figure 24 would be prioritised only by risk reduction, then the measure of deepening water bodies would be ranked higher than e.g. retention ponds, which would have more co-benefits for both nature and people goals.

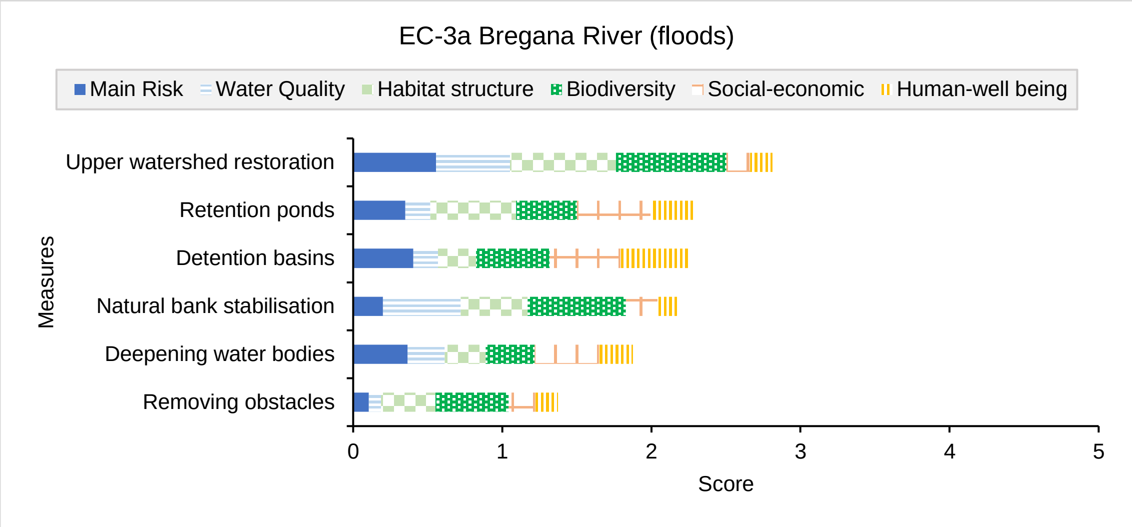



*Figure 24. Example of the ranking of measures for the Bregana River, Croatia (main hazard: floods).*

The partial scores for a selected measure related to the individual goals are also influenced by the stakeholder weights, which may be biased if some stakeholder groups are over-represented in the weighting process. For example, stakeholders with technical background may be biased toward main risk reduction rather than toward environmental and social benefits, while the environmental authorities or activists may be biased toward benefits for nature. This emphasizes the need for a good structure of the stakeholder pool in terms of diversity and size of groups. As shown in the previous subsection, the authorities are represented more than other stakeholder group in Collaborator cases (Figure 19). At the same time, the Collaborators' stakeholder weights for risk reduction are higher than for the nature and people goals. Although this might raise some concern about uncertainties in the prioritisation of measures in Collaborator sites, some preliminary analyses have shown that the results are not excessively sensitive to the stakeholder weights when the measure performance scores related to all goals are included. If the measures would be prioritised only by the criteria of the main risk reduction, this sensitivity would be much higher.

Influence of the stakeholders' weights on the final ranking was investigated by Ruangpan et al. (2021) during the development of the ranking methodology for two cases, Tamnava River in Serbia (EC-3c) and Nangang River in Taiwan (IC-2). The results have shown that the ranking based on performance scores only (i.e., with no stakeholder weights) differs from the ranking when the stakeholder weights are introduced into MCA. Figure 25 gives a comparison of the measure ranks obtained in these two manners. The measures suggested by the criteria but not suitable for the local conditions (e.g., no lakes to be restored) are at the bottom of the list and do not have stakeholder weights and final scores. In both cases, floodplain restoration is the best measure both with and without stakeholder weights. The remaining suitable measures have different ranks when stakeholder weights are introduced. For example, in the Nangang River case, the measures related to widening and deepening of water body were ranked 7$^{th}$ and 8$^{th}$ before including stakeholder weights, while they were ranked 2$^{nd}$ and 5$^{th}$ with the stakeholder weights included. Similarly, in the Tamnava River case, the measures like bypass channels and dike relocation have higher rank with no stakeholder weights.

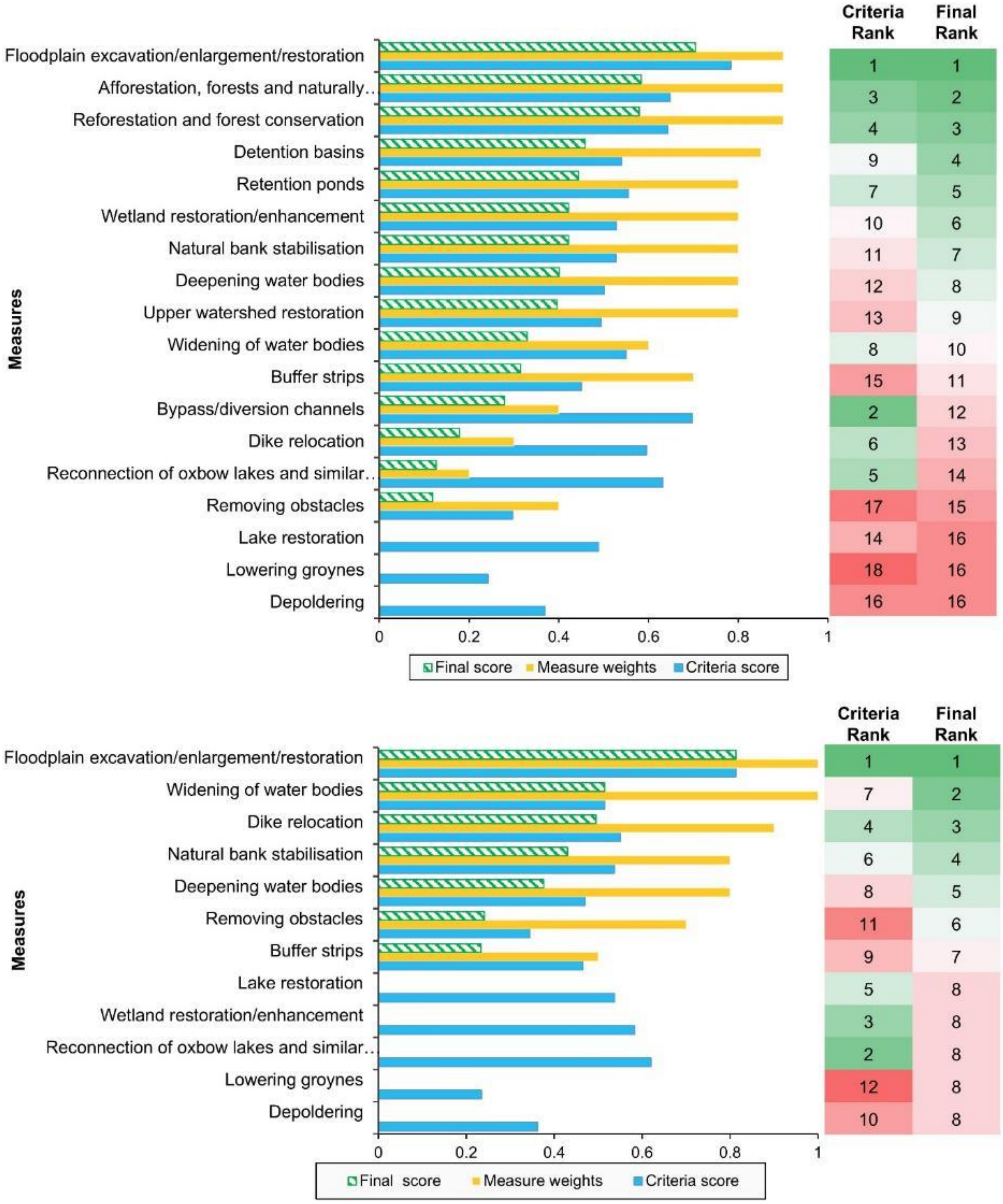



*Figure 25. Comparison of measure ranks for the Tamnava River, Serbia (top) and Nangang River, Taiwan (bottom), based on the performance scores only (Criteria Rank) and with stakeholder weights (Final Rank).*

Note: The scores and the weights are normalised to allow comparisons. Source: Ruangpan et al. (2021).

# 5 Conclusions

Baseline assessment of Collaborator cases aimed at implementation of NBS for reducing hydrometeorological risks includes all relevant elements of the natural environment and the socio-technical system reflecting pre-intervention conditions in the focus areas of Collaborator case studies. Such an assessment is necessary in order to understand relevant factors and interactions influencing implementation of NBS, as well as to support identifying potential measures for resolving the identified challenges and meeting project objectives. The baseline assessment included data and information needed for describing the hazards, including physical characteristics of the area (topography, land use, hydrographic network, soil and geological properties etc.), vulnerabilities, socio-economic conditions, political and regulatory context, main stakeholders, and existing and planned risk reduction measures.

The RECONECT methodology for selecting the measures for reducing hydrometeorological risks was applied in the form of the Measure Selector tool for the Collaborator sites to obtain a preliminary list of appropriate measures, which was then reduced using the expert judgment of the Collaborator partners by excluding the measures that are not suitable for the particular case. The use of the tool has proven to be simple, while the experience from the partners shows that the preliminary list of measures may turn out to be long if the focus area is large and has a variety of conditions (e.g., combined urban and non-urban areas), or if the interventions are desired both in head parts of the watershed and in the flat valleys (e.g., when the flash flood and riverine flood hazards are both present). Since evaluating a long list of potential measures with high technical detail may not be justifiable for the initial project stages (i.e., co-planning and assessment stage), it seems that the further application of the tool for the upscaling purposes should be preceded by a clear disaggregation of the cases into focus areas with different characteristics so that the measure selection tool can propose the measures in a more discriminative manner.

Ranking the selected measures was obtained with a multicriteria analysis (MCA) tool, developed within RECONECT. The methodology for this includes scores for performance of the measures in achieving the goals and sub-goals from the three RECONECT main challenges – water, nature, people – as the criteria in MCA, and the stakeholder opinions on the main goals and sub-goals, used as the weights in MCA. In this way, the stakeholders can participate in the selection of measures regardless of their level of technical knowledge and subsequently affect the final selection of the measures.

The process of measure selection and ranking proved to be very valuable for the development of NBS cases in Collaborator sites. It allowed Collaborator partners to go beyond the technical aspects of their sites and learn more about what their stakeholders perceive as the most important in terms of benefits and co-benefits of NBS. However, in two thirds of Collaborators there is potential bias in the stakeholder weights due to prevailing share of the authorities in the stakeholders' pool. It is therefore recommended that the stakeholder opinions are collected across more uniformly distributed stakeholder groups.

Assessment of the stakeholder weights for goals and subgoals highlights differences across the stakeholder groups on what they find the most important benefits from NBS. These results show the need to involve a wider range of stakeholders and to test researchers' own assumptions on the rationale for NBS. The results indicate that NBS represent different things to different people and that the benefits derived from their implementation should not be assumed. An exploration of priorities and expectations from different stakeholders should therefore be a part of the co-assessment stage of any NBS. Excluding this could lead to opposition at different levels and hinder the process already at the planning stage.

Ranking the measures also proved to be useful for the partners that are less experienced in the risk reduction studies and analysis, as well as for those with different professional background. For example, partners experienced in riverine floods were faced with the need to introduce the erosion control measures in the cases where flash floods were also a significant hazard. This also underlines the dynamic nature of the co-creation process, which needs interdisciplinary approach and multidisciplinary teams.

The results indicate that NBS are perceived amongst Collaborators as instrumental for a wide range of issues. While the interest to implement NBS is in some cases driven by the need to mitigate hazards, in other cases NBS are more attractive than traditional grey infrastructures primarily because of the perceived co-benefits. Although the co-benefits of NBS have long been presented as additional to their mitigating and adaptation functions, the Collaborators expect that the co-benefits of NBS can in fact play a more central role in justifying implementation of NBS than typically hypothesized. Thus, in cases where NBS might not be considered as a first choice for reducing hydro-meteorological hazards, making clearer connections to their co-benefits might influence stakeholders' choice of measures.

However, at this stage of the RECONECT project, the potential NBS in Collaborator sites have not been presented to their key stakeholders yet (this is planned within Task 4.5) and the role and the potential of co-benefits to affect the stakeholder's opinions and choices is not completely clear yet. It is therefore generally recommended to have a validation workshop with stakeholders to present the results of the baseline assessments and preliminary selection of measures and showcase the potential suitable measures for the area.

Further work for RECONECT Collaborators will be founded on their baseline assessments towards assessing the pre-intervention hazard and risks, to be used later for evaluation of performance of the proposed solution by comparing the pre-intervention and post-intervention conditions (Task 4.8). Of equal importance is further mapping of the multi-level policies and institutional and governance feasibility of NBS in Tasks 4.5 and 4.7, since assessing political and regulatory context proved challenging for most Collaborators.

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# Annex A. Survey on stakeholder perceptions

## RECONECT local perceptions for Nature-Based Solutions

This survey aims to collect valuable data that will help in the process of choosing suitable Nature-Based Solutions (NBS) for your area. To analyze the opinions and perceptions of those living and working around the sites where the NBS measures could be implemented, this survey will be shared and completed by different stakeholders. In this way, the most suitable Nature-Based Solutions will be chosen based on expert knowledge, local opinions, and insights from local authorities in the area.

* Required

### General Information

1. Which of the following sectors do you represent?*

*Check all that apply.*

- ▢ Local authority
- ▢ Civil Society/NGO´s
- ▢ Political representative
- ▢ Academia
- ▢ Local citizen
- ▢ Other:

2. In which of the following age groups would you classify yourself?*

*Check all that apply.*

- ▢ 18-29
- ▢ 30-49
- ▢ 50-69
- ▢ More than 70

### Instructions- How to complete this survey

The survey consists of six sections: hydro-meteorological risk, water quality, habitat structure, biodiversity, socio-economic and cultural contributions, and human well-being. Inside each section, you will find different questions that describe the benefits that the area might receive if NBS measures were carried out. You are asked to give a score from 0 to 10 for each of the questions. Your answers should reflect how important it is for you to obtain that benefit in your area. A value of 0 represents NOT IMPORTANT, and a value of 10 means the MOST IMPORTANT. In case you don´t know about the topic and cannot provide a score please select the option "Don´t know". At the end of each section, you will be asked to give an overall score to the section. Please add an overall score from 0 - 10 in your answer and explain why you gave that score to that section.

For example - "Habitat structure"

Overall score: 4

I give this value to habitat structure because I would like to preserve the green areas around my town. I consider it to be very important, but my area is already quite green, that is why I am giving it a 4.

**At the end of this survey, you will find an additional section called "co-monitoring". This section will allow us to monitor your participation in this project.

## Hydro-meteorological risk

Hydro-meteorological hazards are of atmospheric, hydrological or oceanographic origin. Examples are floods (flash floods; riverine floods; and coastal storm surges), drought, and landslides. This section evaluates the hydro-meteorological risks that are present in the chosen area. Your answers will reflect the need for reducing them.

### 3. Flood risk reduction in urban and rural areas or around rivers, lakes, watercourses*

How important is it for you to implement measures that can prevent floods in your area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 4. Coastal flood risk reduction*

If you live near the coast, how important is for you to implement measures that can prevent floods derived from sea level rise? If you do not live near the coast, please select "doesn´t apply"

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

▢ Doesn´t apply

### 5. Groundwater management*

A stable groundwater level contributes significantly to the security of the water supply and has an impact on local vegetation. If you know about the status of the groundwater around your area, how important is it for you to implement measures that can guarantee good groundwater levels in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 6. Drought risk reduction*

Droughts can have negative impacts on the amount of water availability and distribution, crops irrigation, local flora and fauna, and health. What importance do you place on implementing measures that can prevent droughts in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 7. Landslide risk reduction*

Landslides can be caused by the movement of rock, earth, or debris down a sloped section of land. They can be triggered by intensive rainfall, earthquakes, or rapid stream erosion. What importance do you place on implementing measures that can prevent landslides in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 8. Final score for the Hydro-metrological risk section*

Please give an overall score to the section which reflects the importance that you put on reducing the impacts of different water-related hazards. Please at the beginning of your answer put a score from 0 to 10 and then explain why you gave this score.

## Water Quality

Water quality is an essential factor since it enhances healthy ecosystems and human well-being. This section evaluates the importance of improving the overall water quality, including surface and groundwater bodies in the area.

### 9. Improve water quality in rivers/watercourses/lakes/ponds*

Good water quality in surface water bodies like rivers and lakes can contribute to improve ecological and human health. What importance do you place on implementing measures that can help improve the water quality in rivers, lakes and ponds around your area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 10. Improve coastal water quality*

Good water quality in coastal areas can contribute to reducing dangerous conditions for marine life and human health. What importance do you place on implementing measures that can help improve the coastal water quality around your area? If you do not live near the coast, please select "doesn´t apply"

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 11. Improve groundwater quality*

Groundwater is a very important source in terms of drinking water supply in some countries. Groundwater quality is less prone to contamination than surface water but can also be affected by various pollution sources. What importance do you place on implementing measures that can help improve the groundwater quality in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 12. Final score for Water quality section*

Please give an overall score to the Water quality section which reflects how much you value having good water quality in your area. Please put a score from 1-10 at the beginning of your answer and then explain why you gave this score.

## Habitat structure

Habitat structure refers to having green areas, blue areas, and the built environment of sufficient quantity and quality with the balanced distribution. This section evaluates the importance of preserving the natural environment that surrounds your area.

### 13. Increase habitat area*

Increasing the habitat area (i.e aquatic, wetland and terrestrial habitats for local species) can have significant effects on the persistence of various species. Increasing green space can improve population growth and reduce the risk of species extinction. What importance do you place on increasing room for habitat in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

14. Habitat provision and distribution (quality)*

Habitat provision and distribution refers to how different habitats are interconnected. Improving habitat connectivity leads to richer ecosystems where there is more diversity of animals and plants, leading to better overall ecosystem health. What importance do you place on improving the quality of habitat in the area, such as habitat connectivity?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

15. To reflect the ecological status and physical structure of habitats*

Reflecting on the ecological status and physical structure of habitats refers to monitoring and carrying out conservation and protection strategies to track changes of flora and fauna throughout time. What importance do you place on monitoring and carrying out conservation and protection strategies for the habitats in your area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

16. Land-use type*

NBS measures have the potential to be implemented in different locations around your area. However, this may imply that some land could potentially be changed to build such measures. To prevent conflicts in those areas and provide sustainable solutions, it is important to have consent from the people around the area. What importance do you place on choosing the right land for possible implementation of NBS measures in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

17. Final scoring for Habitat structure section*

Please give an overall score to the Habitat Structure section which reflects how much you value having or preserving blue/green spaces near your area. Please put a score from 1-10 at the beginning of your answer and then explain why you gave this score.

## Biodiversity

Biodiversity refers to the variety of life on earth (plants and animals). This section evaluates the importance of preserving ecosystems to guarantee that various species can interact and live without disturbances.

18. To maintain and enhance biodiversity*

Maintaining and enhancing biodiversity means improving number and types of protected plants and animals, native species and their density and diversity in general. What importance do you place on the maintenance and enhancement of biodiversity in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

19. Reduce disturbance to ecosystems*

Reducing the disturbance to the ecosystem means to decrease disruptions to the normal functioning of the ecosystem, for example: The construction of new NBS measures could introduce new nonnative animals and plants, this could create problems to the current ecosystems. What importance do you place on reducing the disturbance to ecosystems in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 20. Final scoring for Biodiversity section *

Please give an overall score to the Biodiversity section which reflects how much you value preserving or modifying the landscape around your area, having in mind that this could impact the plants and animals that exist now. Please put a score from 1-10 at the beginning of your answer and then explain why you gave this score.

## Socio-economic and cultural contributions

This section evaluates how the implementation of NBS measures can promote socio-economic and cultural development in the area.

### 21. Increase recreational opportunities*

The implementation of certain NBS measures can create recreation opportunities some examples are parks, fishing ponds, bird watching areas. These can be beneficial for human well-being from both physical and mental aspects.What importance do you place on increasing recreational opportunities in the area

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 22. Education and Awareness*

The implementation of certain NBS measures can create opportunities to provide knowledge and awareness about ecosystem preservation, sustainability, ecology, green infrastructure, among others. What importance do you place on improving educational/awareness on environmental subjects through the implementation of NBS in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 23. Maintain and if possible enhance cultural values*

The implementation of certain NBS measures can help maintain and if possible, enhance cultural local values present in the area such as conservation techniques and traditions. What importance do you place on maintaining or enhancing cultural values in the area?

### 24. Accessibility*

Accessibility reflects on the factor of how easy it may be for you to reach/ access an NBS site. This can also mean that the implementation of an NBS around your area can incentivize people from outside to visit it. How important is it for you that the NBS measure in your area could be easily accessible by you and others?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 25. Improve community cohesion*

Community cohesion is enhanced when people are engaged in an activity that connects them. The implementation of NBS measures in a community or neighborhood can create a feeling of attachment to the area as it is a more pleasant place to live and connect to others. What importance do you place on improving community cohesion in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 26. Stimulate/increase economic benefits*

The implementation of NBS measures can help increase or stimulate economic growth in the area, for example by reducing future damage costs created by a hazard or by reducing energy consumption costs. What importance do you place on stimulating/increasing economic benefits in the area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 27. Encourage new business models*

Some NBS measures can increase the attractiveness of an area, and this could attract new business investments which could improve living and working conditions. What importance do you place on possibly creating new business opportunities through the implementation of certain NBS measures around your area?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

### 28. Final scoring for Socio-economic section*

Please give an overall score to the Socio-economic section which reflects how much you value the possibility that NBS measures can support or create services that may lead to improve the productivity and economy around your area. Please put a score from 1-10 at the beginning of your answer and then explain why you gave this score.

## Human well-being

NBS have the potential to improve both mental health (e.g. feelings of wellbeing) and physical health (e.g. improved air quality and associated health outcomes). This section evaluates some of the health and wellbeing benefits that NBS can bring to the people living around them.

### 29. Health and well-being impacts*

Health benefits can be considered in terms of mental and physical aspects. The implementation of NBS measures can help improve the health of the people living around them. For instance by increasing their physical activity by spending more time outside. How much you value that human health and well-being of local citizens in the area can be improved through the implementation of an NBS?

*Mark only one oval.*

▢ 0 ▢ 1 ▢ 2 ▢ 3 ▢ 4 ▢ 5 ▢ 6 ▢ 7 ▢ 8 ▢ 9 ▢ 10 ▢ Don't know

## Co-creation monitoring

This section will allow us to monitor your current and future involvement in the project. The RECONECT project will be running until 2023 and we are planning activities to include your insights for the design and possible implementation of Nature-Based Solutions in your area. First we ask about more general engagement with research or innovation activities in your area, and then we ask specifically about engagement in RECONECT.

1. Do you feel that the information you provide about your area is valued during local research or innovation projects? *

*Mark only one oval.*

- ▢ Not applicable, I have never provided information into research or innovation projects before RECONECT
- ▢ Not valued at all
- ▢ A little valued
- ▢ Somewhat valued
- ▢ Extremely valued

2. How familiar are you with the research, information or knowledge that local research centers and universities produce for your area?*

*Mark only one oval.*

- ▢ Not familiar
- ▢ A little familiar
- ▢ Somewhat familiar
- ▢ Very familiar

3.If you answered positive to the above question, select the entity you are familiar with:*

*Check all that apply.*

- ▢ Local university
- ▢ Local government authority
- ▢ Local research center
- ▢ Other:

4. Has working with local research centers or universities lead to you obtaining valuable information for your work activities?*

*Mark only one oval.*

- ▢ Not applicable, I have had no interaction with local research centers or universities
- ▢ Not at all valuable
- ▢ A little valuable
- ▢ Somewhat valuable
- ▢ Extremely valuable

5. In which of the following activities in the RECONECT project have you been asked to give input, or have you been involved?*

*Check all that apply.*

- ▢ Selection of an area where Nature Based Solution (NBS) measures could be implemented
- ▢ Ranking of applicable NBS measures for your area
- ▢ Input into benefits that NBS measures can provide to your area
- ▢ Input into hazards in your area
- ▢ Input into vulnerabilities in your area
- ▢ Input about relevant government policies or procedures in your area
- ▢ Received project progress updates or invitations to information meetings

- ▢ Other:

6. In which way/s were you contacted to participate in any of the above activities related to the RECONNECT project in your area?*

*Check all that apply.*

- ▢ In person meeting
- ▢ Virtual meeting
- ▢ Phone call
- ▢ Seminar/workshop
- ▢ E-mail
- ▢ Traditional paper mail
- ▢ Social media advertising
- ▢ Other:

7. In which of the following participatory methodologies from the RECONECT project have you been involved?*

*Mark only one oval per row.*

| | Yes | No | I am not sure |
|---|---|---|---|
| Formal or informal interviews | ▢ | ▢ | ▢ |
| Online or paper surveys | ▢ | ▢ | ▢ |
| Participatory mapping | ▢ | ▢ | ▢ |
| Trying out of interactive tools | ▢ | ▢ | ▢ |
| Sending/collecting local data that can help the project coordinators | ▢ | ▢ | ▢ |
| Workshops for proposing ideas that can improve the project | ▢ | ▢ | ▢ |
| Formal or informal interviews | ▢ | ▢ | ▢ |
| Online or paper surveys | ▢ | ▢ | ▢ |
| Participatory mapping | ▢ | ▢ | ▢ |
| Trying out of interactive tools | ▢ | ▢ | ▢ |
| Sending/collecting local data that can help the project coordinators | ▢ | ▢ | ▢ |
| Workshops for proposing ideas that can improve the project | ▢ | ▢ | ▢ |

Thanks for your time and cooperation. We hope to continue engaging with you in the near future.

# Annex B. Ranking of measures in Collaborator cases based on MCA

This Annex provides the results of multicriteria analysis (MCA) of potential NBS in Collaborator site, taking into account stakeholder opinions on six main goals (hydro-meteorological risk reduction, water quality, habitat structure, biodiversity, socio-economic aspects, and human well-being), as well as a range of subgoals. The final scoring of measures, shown in the figures in this Annex, is based on objective scores for measure performance against given goals and weights provided by stakeholders. The main hazards for each Collaborator are indicated in the graph titles.

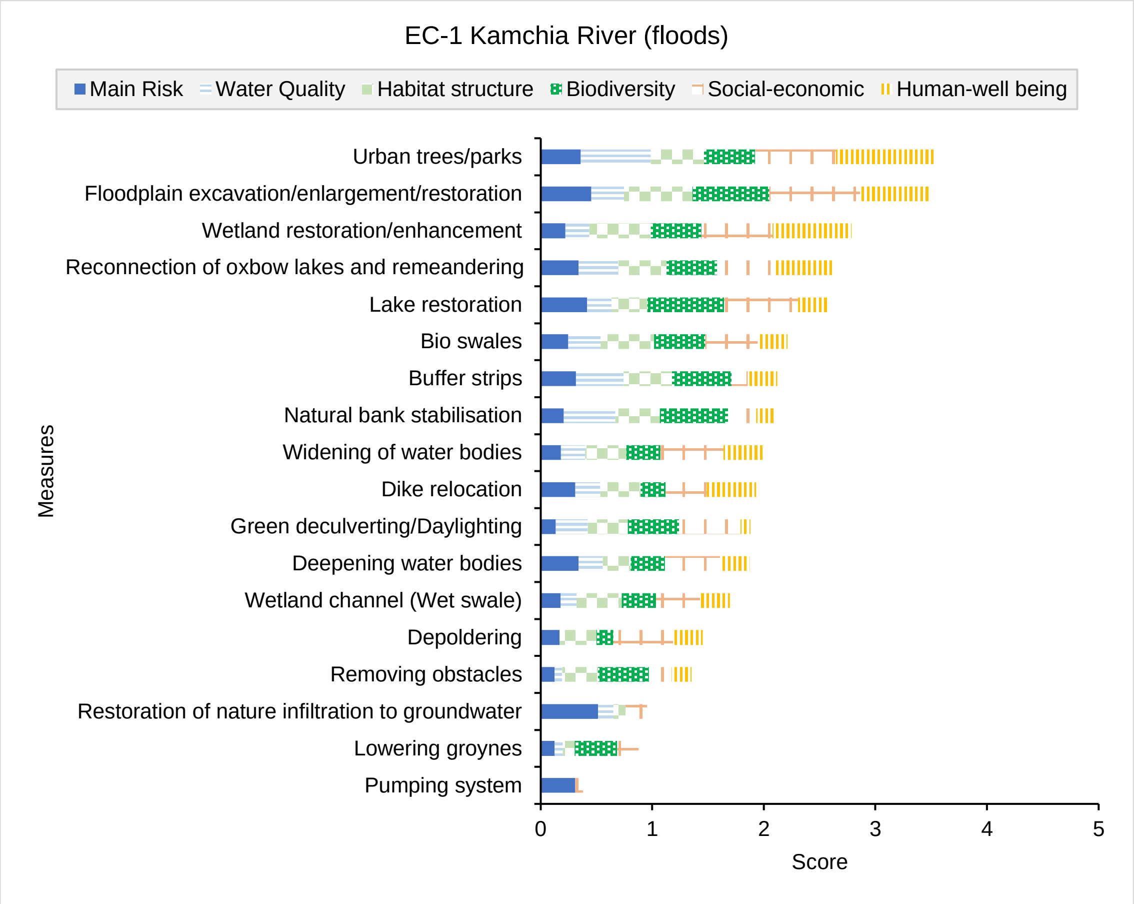


*Figure 26. MCA based ranking of measures for EC-1 Collaborator.*

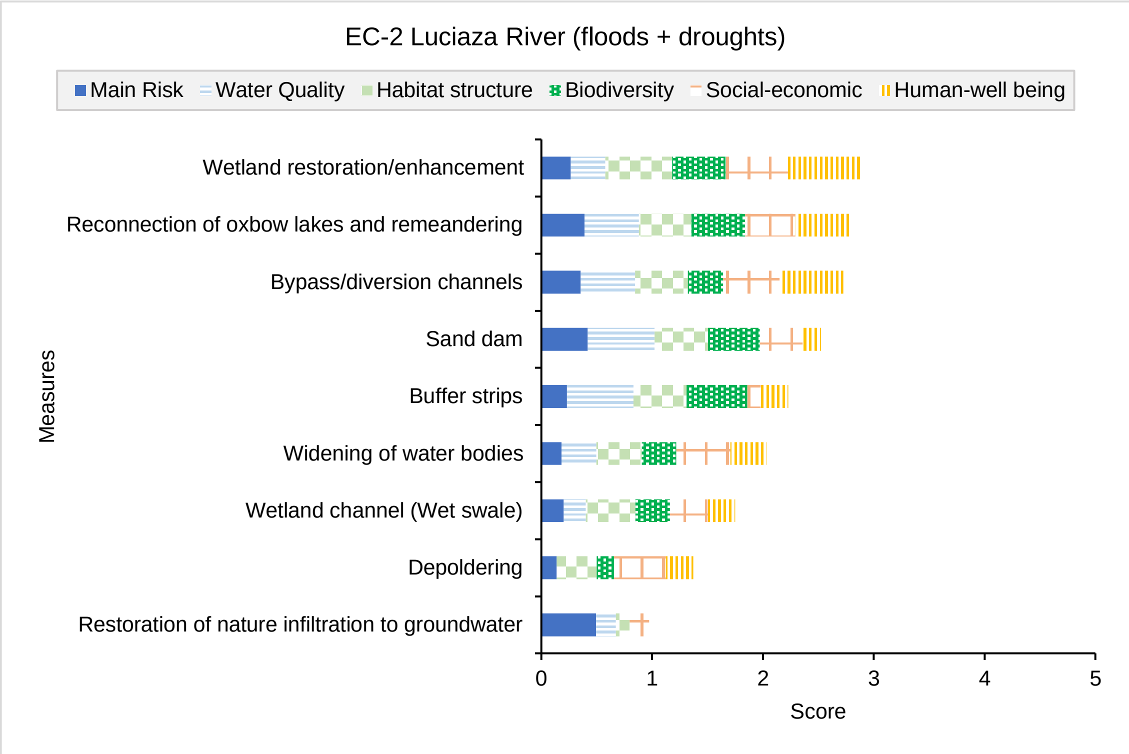


*Figure 27. MCA based ranking of measures for EC-2 Collaborator.*

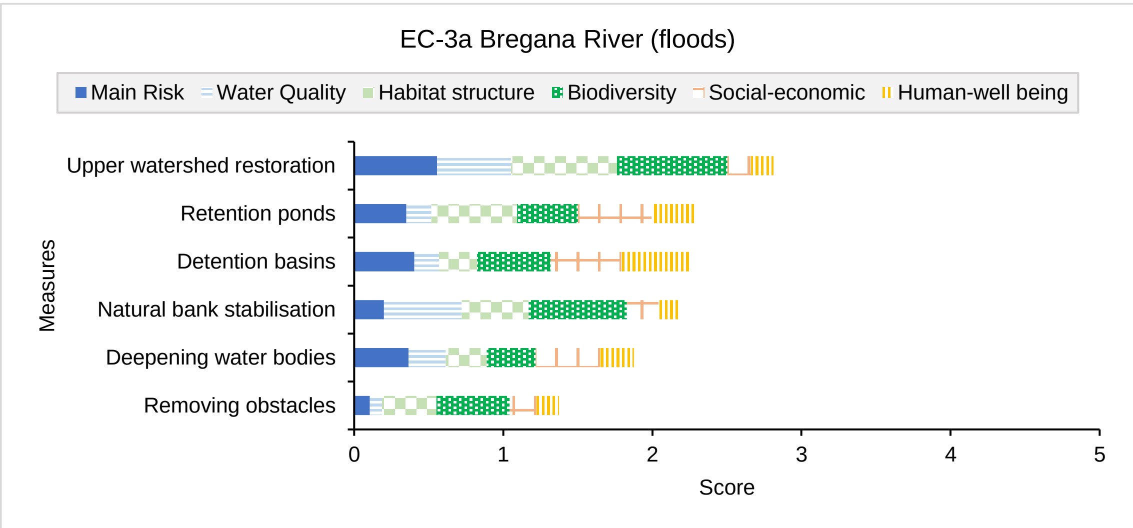


*Figure 28. MCA based ranking of measures for EC-3a Collaborator.*

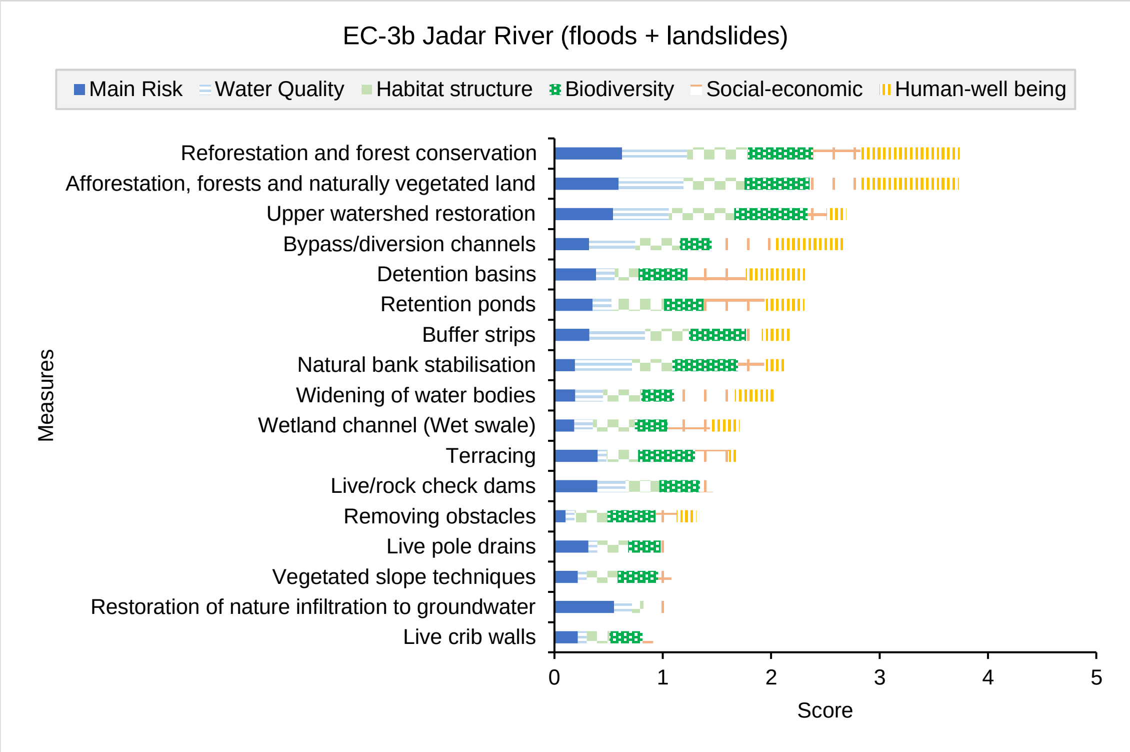


*Figure 29. MCA based ranking of measures for EC-3b Collaborator.*

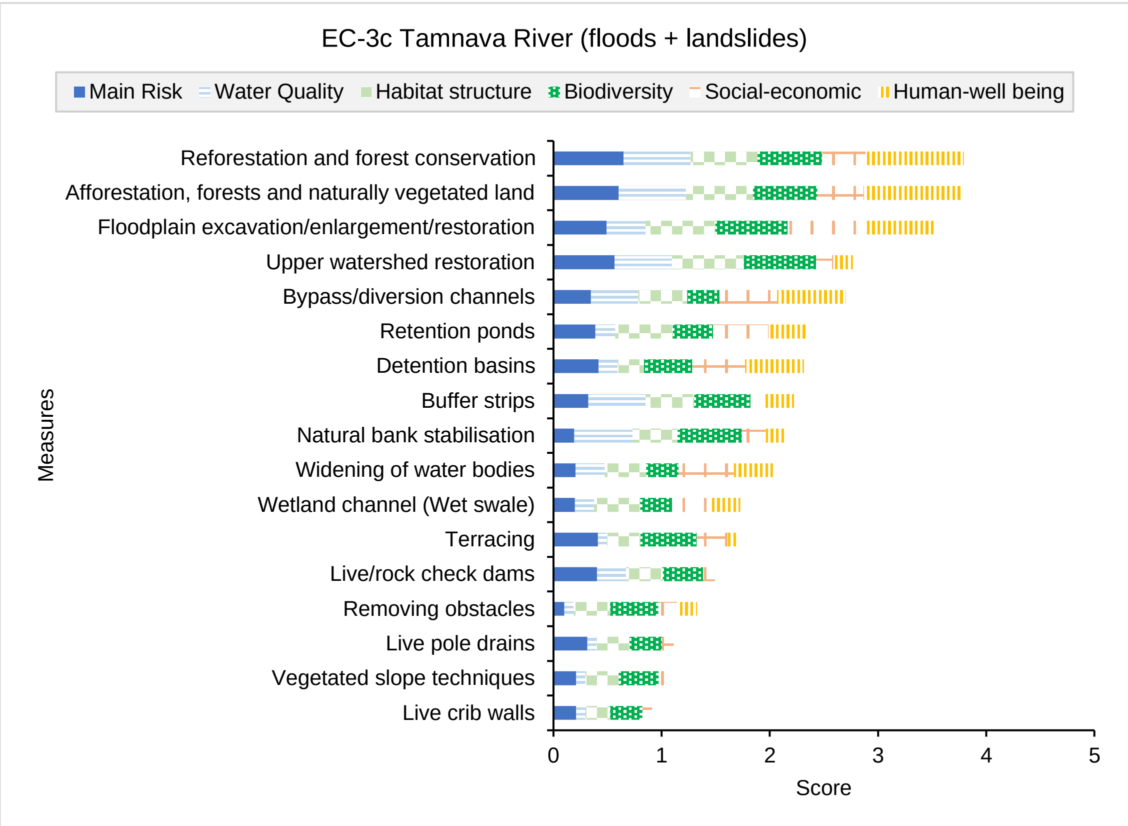


*Figure 30. MCA based ranking of measures for EC-3c Collaborator.*

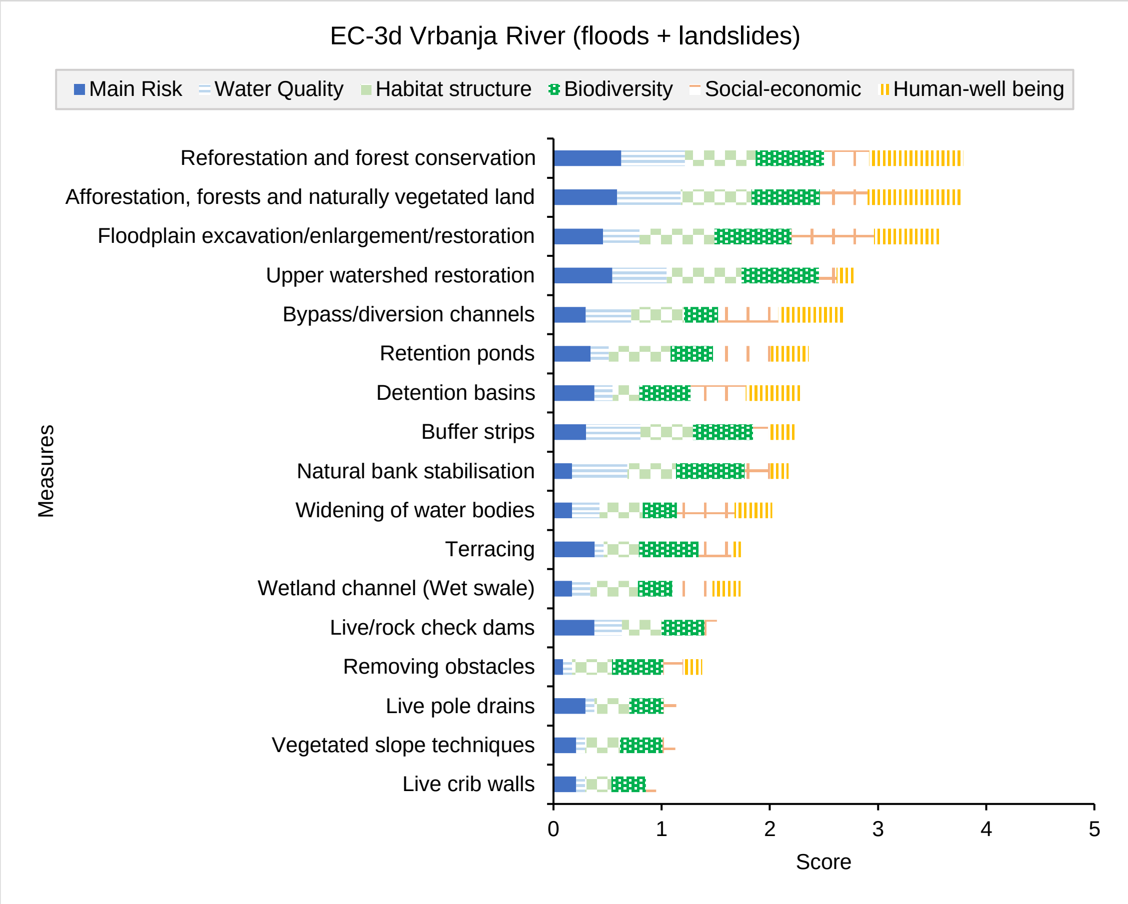


*Figure 31. MCA based ranking of measures for EC-3d Collaborator.*

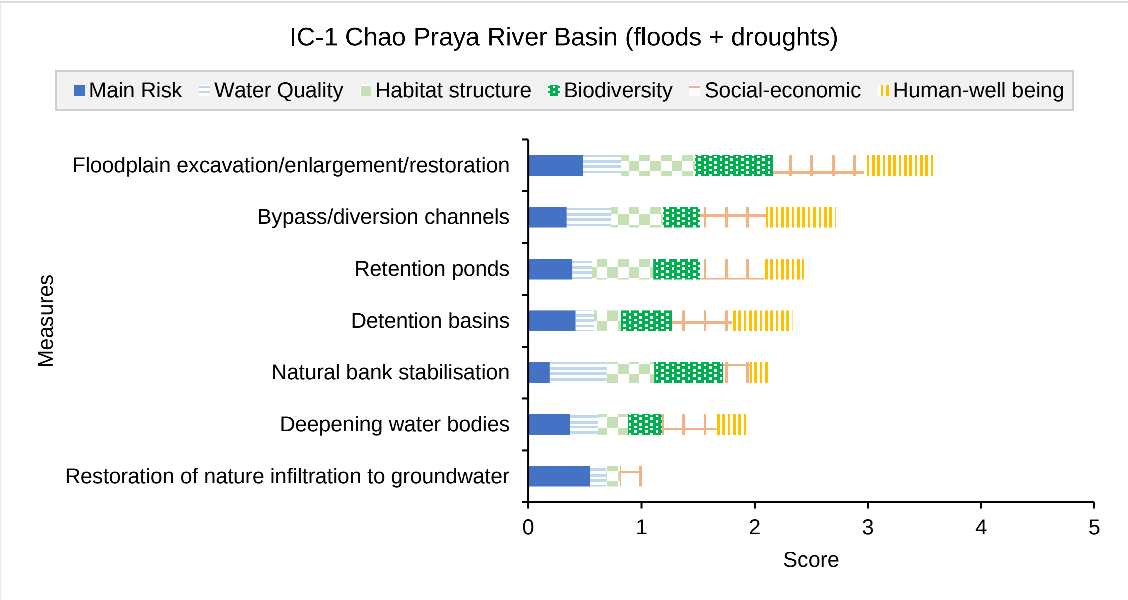


*Figure 32. MCA based ranking of measures for IC-1 Collaborator.*

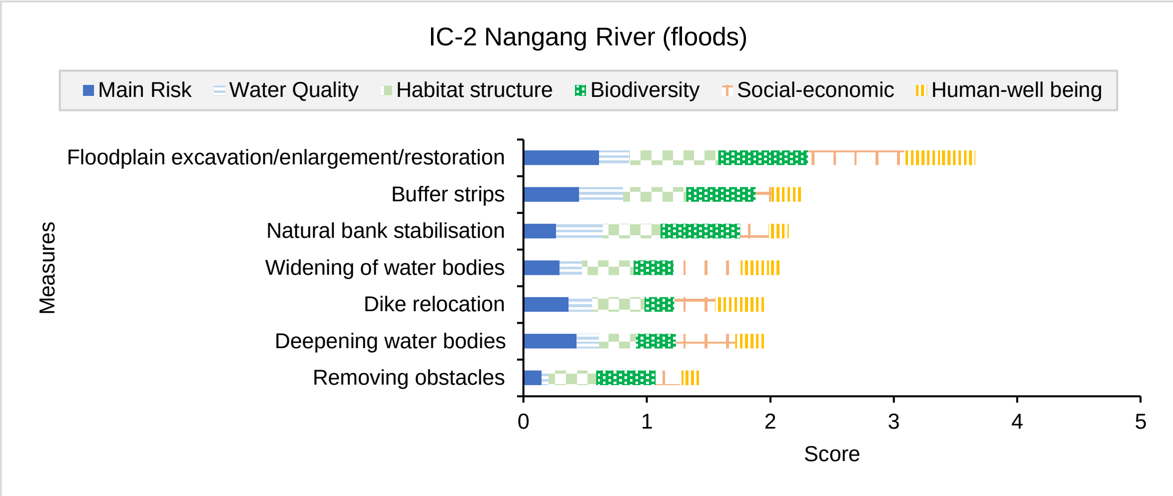


*Figure 33. MCA based ranking of measures for IC-2 Collaborator.*

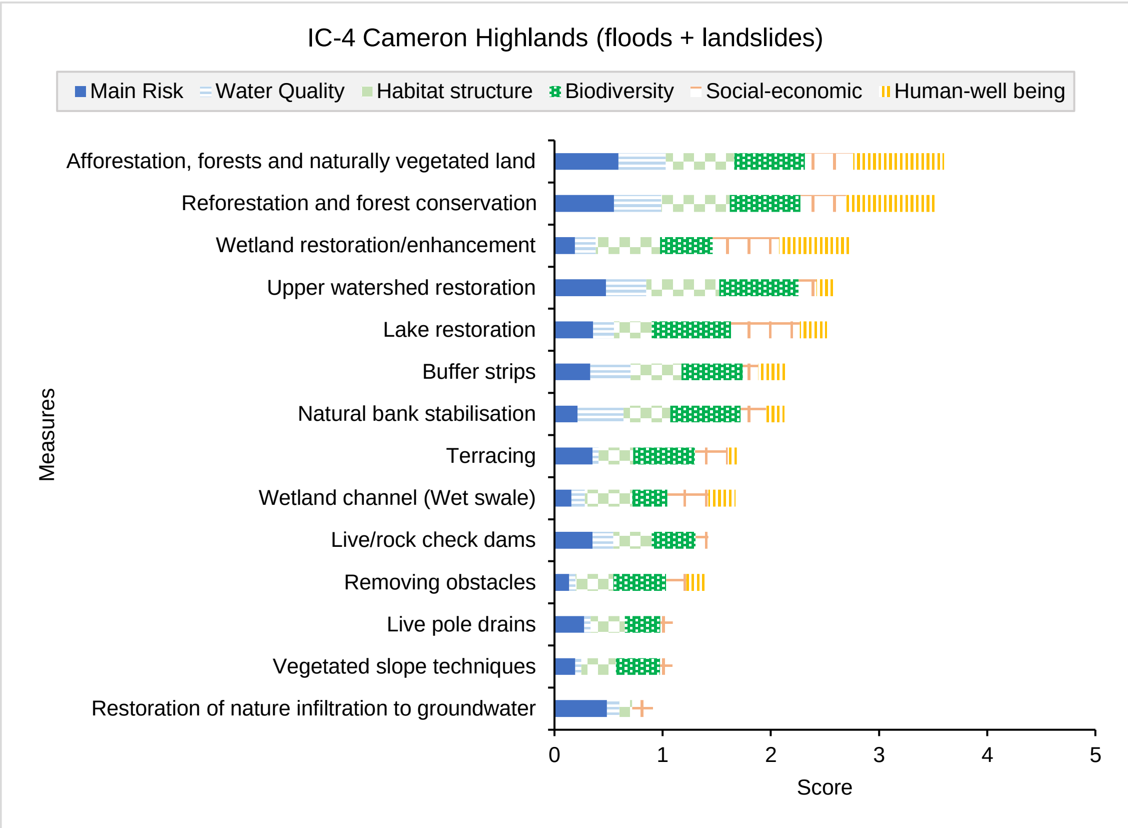


*Figure 34. MCA based ranking of measures for IC-4 Collaborator.*

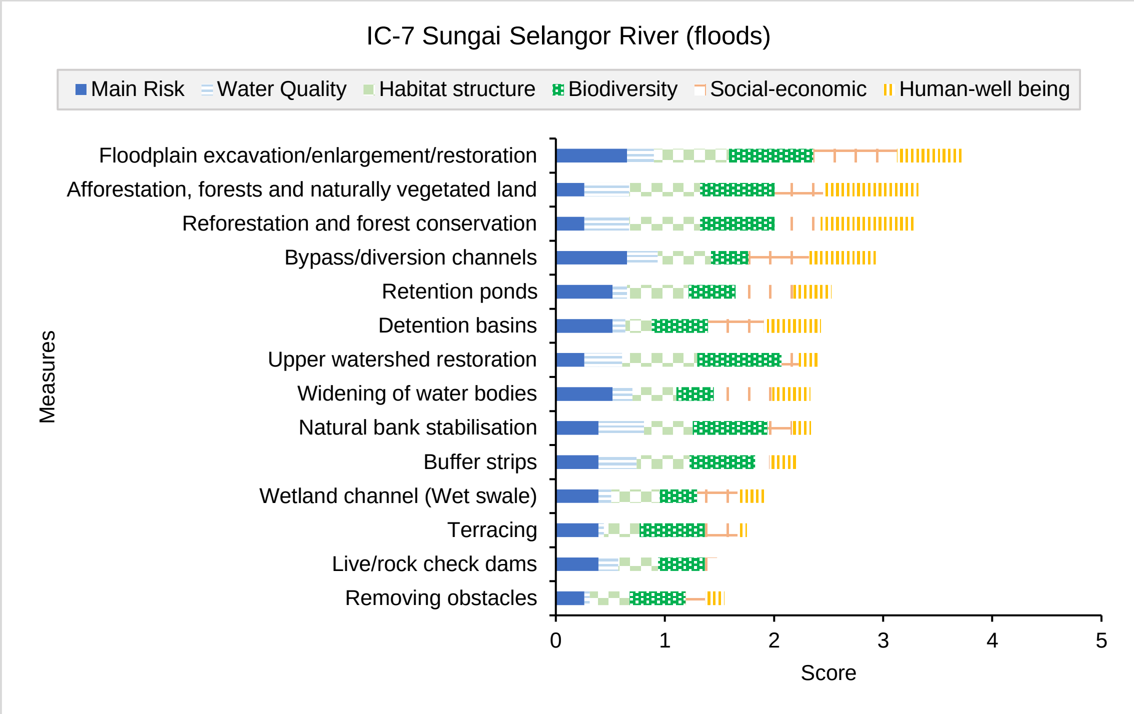


*Figure 35. MCA based ranking of measures for IC-7 Collaborator.*

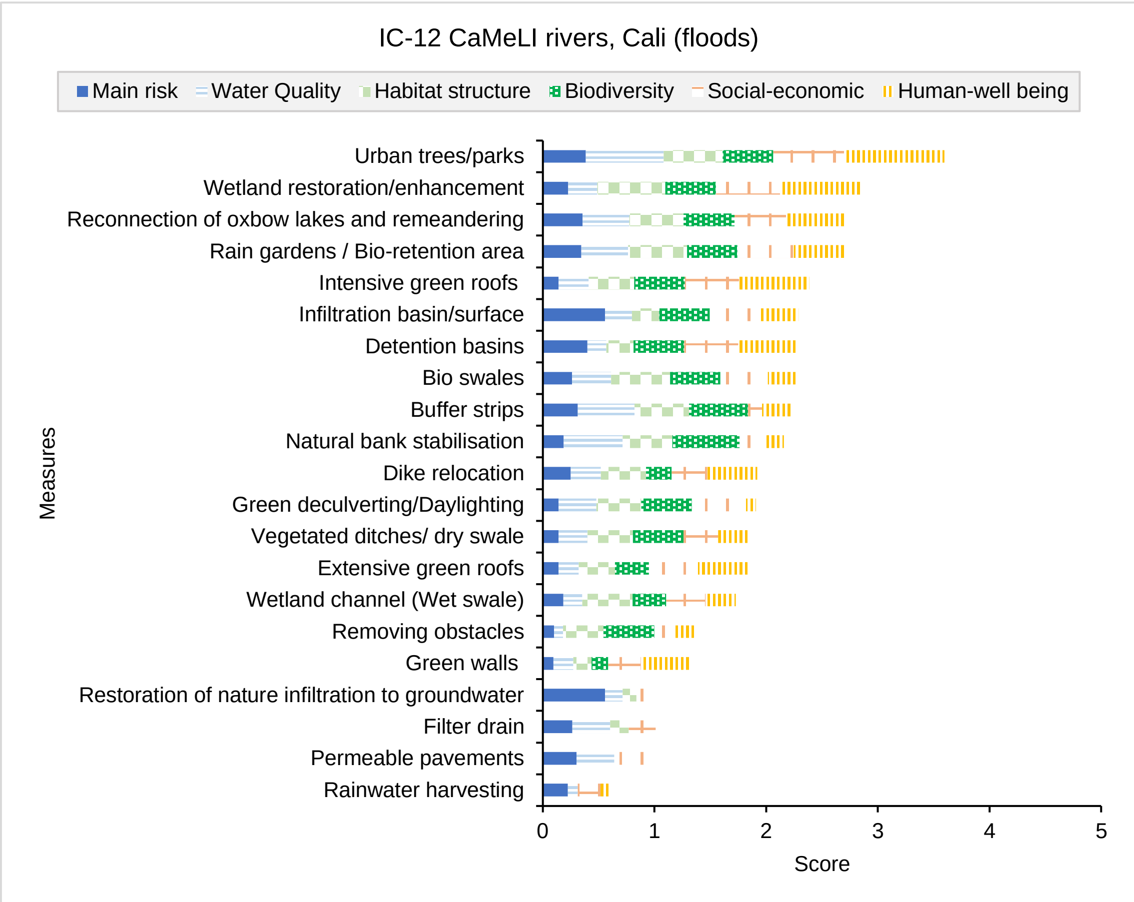


*Figure 36. MCA based ranking of measures for IC-12 Collaborator.*

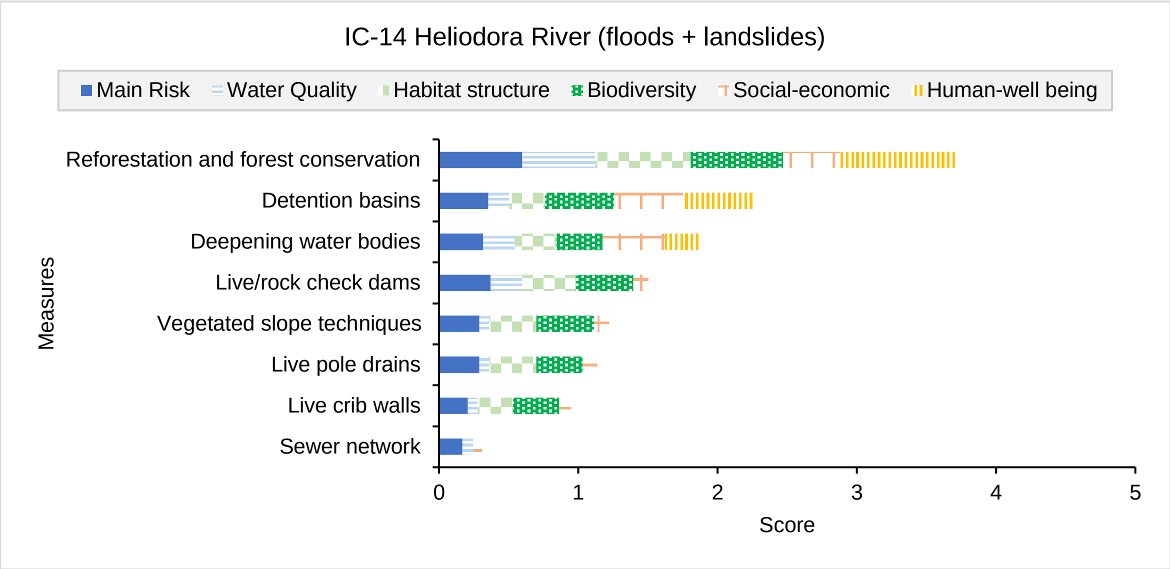


*Figure 37. MCA based ranking of measures for IC-14 Collaborator.*