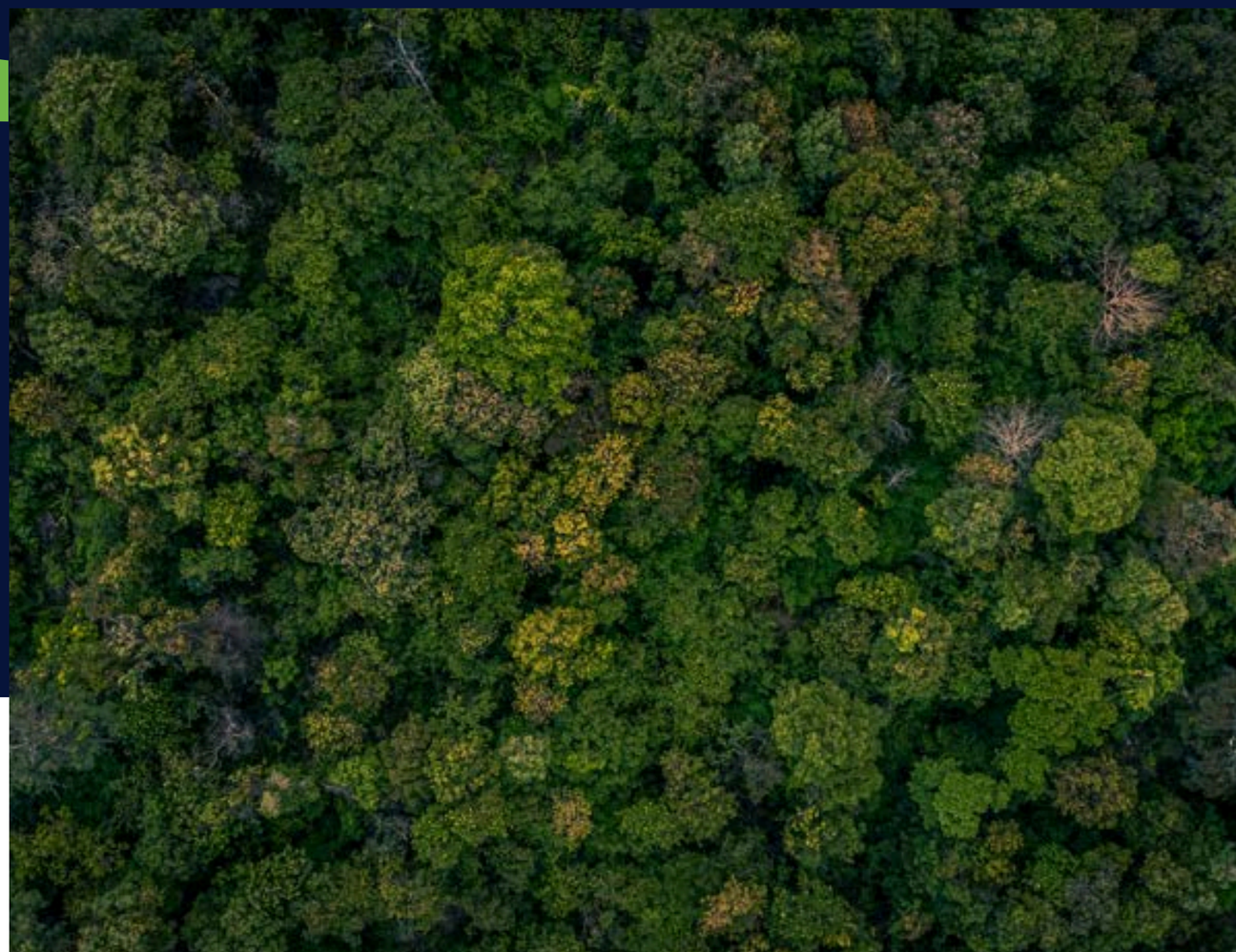
IIS
INTERNATIONAL INSTITUTE
FOR SUSTAINABILITY

PROJECT

DECISION-MAKING IN ENVIRONMENTAL DISASTER MANAGEMENT THROUGH NATURE-BASED SOLUTIONS

HANDBOOK

A NATURE-BASED SOLUTIONS FRAMEWORK FOR MANAGING ENVIRONMENTAL DISASTER RISKS



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The International Institute for Sustainability (IIS) is a non-profit organisation based in Rio de Janeiro (Brazil), dedicated to producing applied knowledge to promote sustainable development. It works in areas such as climate, biodiversity, green infrastructure and nature-based solutions, seeking to integrate science, public policy and society.

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WINNER OF THE ES SCENARIOS MODELLING INITIATIVE
The project was one of the five winners of the "ES Scenarios Modelling Initiative", promoted by the Swiss Re Foundation, in partnership with the AXA Research Fund and WWF, with technical support from EY. The initiative supports the development of biodiversity and ecosystem services (ES) scenarios that are both scientifically robust and applicable by governments and businesses to assess risks and guide resilience policies. The recognition highlights the project's relevance in proposing innovative solutions to address biodiversity loss, supporting the formulation of global adaptation and sustainability strategies.

WINNER OF THE MAPBIOMAS AWARD 2025
The project was one of the winners of the 7th MapBiomas Award in the Climate Emergency category. The award ceremony took place on 7 July 2025, in São Paulo, Brazil. The award, held in partnership with the Ciência Hoje Institute, recognised nine projects that encouraged and expanded applications using data from any MapBiomas product, module or initiative, which involves a collaborative, multi-institutional network of more than 100 institutions across 14 countries.

LEARN MORE ABOUT THE STUDY:

INTRODUCTION

This document presents a guide for the management of environmental disaster risks through the implementation of Nature-based Solutions (NbS), providing a framework to support decision-making and planning processes for climate adaptation.

The approach integrates data on ecosystem services (ES), biodiversity and social vulnerability, and identifies priority areas for interventions, guiding investments that will generate the greatest social and environmental benefits.

The state of Rio de Janeiro (RJ) was chosen as the case study, but the tool is adaptable to different contexts and local needs.

The results for RJ indicated that NbS implemented in priority areas could deliver significant improvements for:

- FLOOD RISK-REDUCTION
- THERMAL COMFORT
- COASTAL PROTECTION

Nature-based Solutions (NbS)

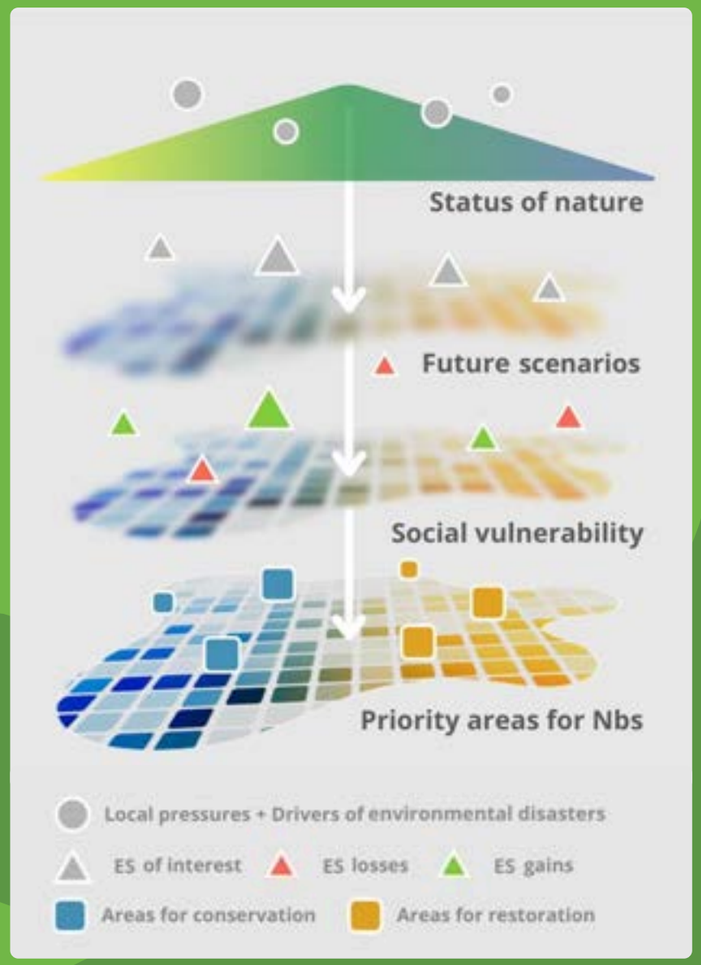
Actions that protect, restore or manage ecosystems to address global societal challenges, delivering benefits for both nature and people in an ecologically sustainable, socially equitable and economically viable way.
(IUCN, 2016).

The Rio de Janeiro Climate Change Adaptation Plan (SEA/INEA, 2018) was the basis for the development of the case study. The historical land-use series from the MapBiomas project (MapBiomas, 2023), as well as various climate and soil databases, were also used to support the modelling of ES under different scenarios.

CONCEPTUAL FRAMEWORK

THIS TOOL IS COMPOSED OF A CONCEPTUAL AND AN OPERATIONAL FRAMEWORKS.

The conceptual framework highlights the key elements that should be considered by decision-makers in the implementation of NbS for environmental disaster risk management. It is both a visual and theoretical synthesis of the environmental risk management process with a focus on NbS. It starts with the identification of local drivers and pressures of environmental disasters, which affect the state of nature (biodiversity, ES and cultural and socio-economic aspects). From this point, the priority ES are defined for the analysis of potential gains or losses in future scenarios. The overlay of these results with social vulnerability data determines the priority areas for the implementation of NbS.



RECOMMENDATIONS FOR APPLICATION

Use updated and validated spatial data.

Adapt the framework to regional conditions and local needs.

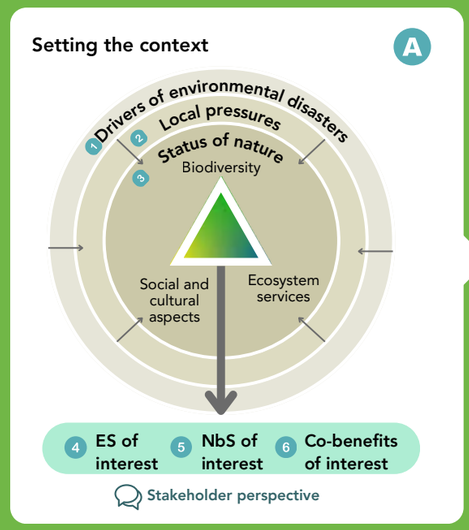
Explore the co-benefits of the chosen NbS.

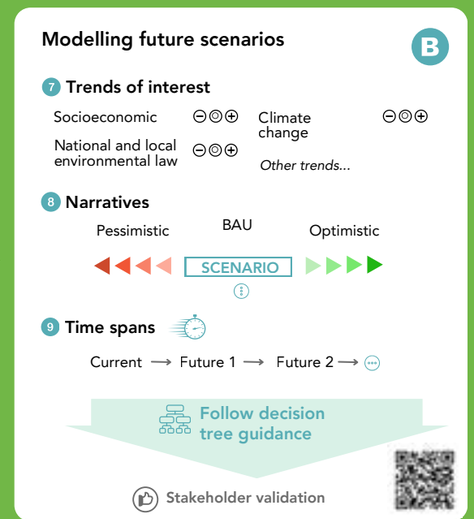
Prioritise areas with higher social vulnerability.

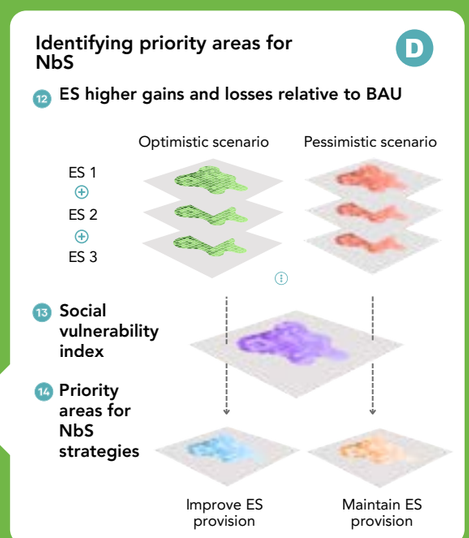
Engage local stakeholders throughout the process.

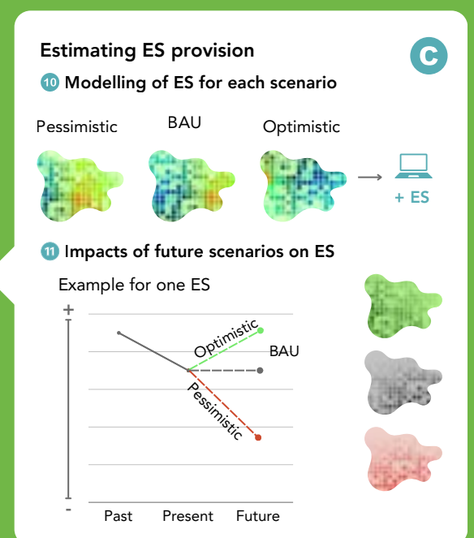
OPERATIONAL FRAMEWORK

The operational framework follows a four-step structure (A, B, C and D), each consisting of a set of steps that together provide a replicable and adaptable methodology for any region of interest. The starting point is to understand and identify the factors that contribute to environmental disasters, the state of nature, the ES, and the NbS of interest, as well as their potential co-benefits. Next, simulations of future scenarios as optimistic, pessimistic and business-as-usual (BAU) are carried out to determine their impacts on the ES in question and to define areas of greater gain or loss in the provision of these services. These same areas are then weighted by social vulnerability indicators. In this way, priority locations for the implementation of NbS are identified, along with their costs and potential co-benefits.







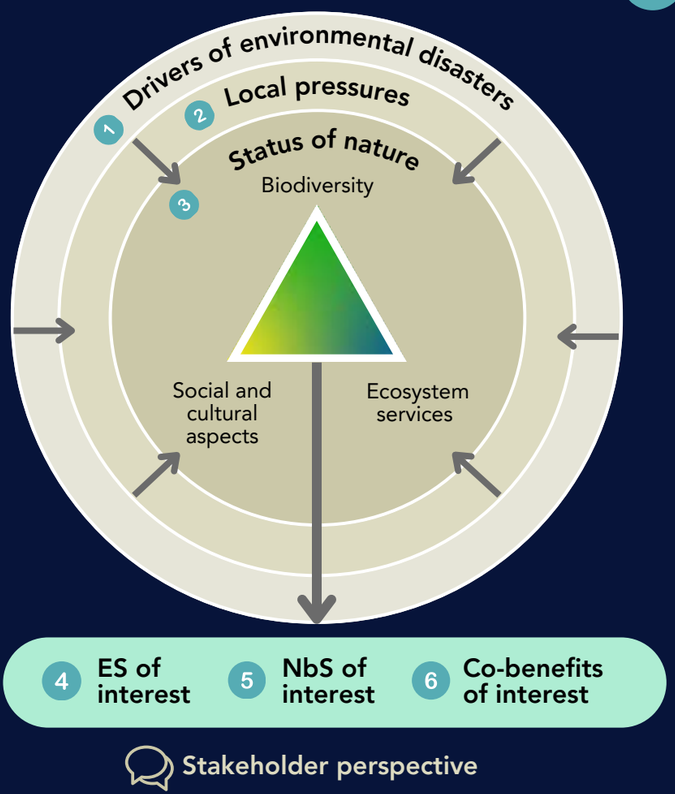


15 Quantifying costs and co-benefits
Stakeholder validation

16 Informing decision-making

Setting the Context

A



Step A - Definition of the socio-environmental context.

In Step A, the socio-environmental context and local demands are analysed and defined, along with the risk drivers for environmental disasters, the main pressures and the state of nature (including aspects related to biodiversity, the provision of ES and socio-cultural dimensions).
Based on this, the ES to be prioritised are selected, the most suitable NbS for the context are identified and the expected co-benefits are outlined.

The participation of local actors is essential to incorporate knowledge, values, and priorities into the process, ensuring results that are more relevant and widely accepted.

APPLICATION IN RJ

The state of RJ was chosen as a case study due to its high vulnerability to the impacts of climate change (e.g. sea level rise, floods, increased rainfall, and heat islands), compounded by high social inequality and population density.

CONTEXT DEFINITION AND SCENARIO BUILDING

MAIN DRIVERS:
climate change and land-use change.

MAIN PRESSURES:
deforestation, urban expansion and extreme weather events.

ECOSYSTEM SERVICES:
flood risk-reduction, thermal comfort and coastal protection

NATURE-BASED SOLUTIONS:
restoration and conservation of native vegetation

CO-BENEFITS:
biodiversity conservation and carbon stock

SCENARIO NARRATIVES | 3 ALTERNATIVE FUTURES (2050)

Local pressures	Business-as-usual	Optimistic scenario	Pessimistic scenario
Urban pressure	Business-as-usual	Reduction	Increase
Vegetation cover	Business-as-usual	Increase	Reduction
Agricultural use	Business-as-usual	Moderate reduction	Increase
Environmental law	Business-as-usual	Compliance with environmental laws	Non-compliance with environmental laws
Climate change	Extreme climate events	Extreme climate events	Extreme climate events

Definition of the pressures considered in each scenario in the state of RJ.

STEP B - MODELLING FUTURE SCENARIOS

Modelling future scenarios

B

7 Trends of interest

Socioeconomic ⊖◎⊕

Climate change ⊖◎⊕

National and local environmental law ⊖◎⊕

Other trends...

8 Narratives

Pessimistic — BAU — Optimistic

SCENARIO

9 Time spans

Current → Future 1 → Future 2 → ...

Follow decision tree guidance

Stakeholder validation

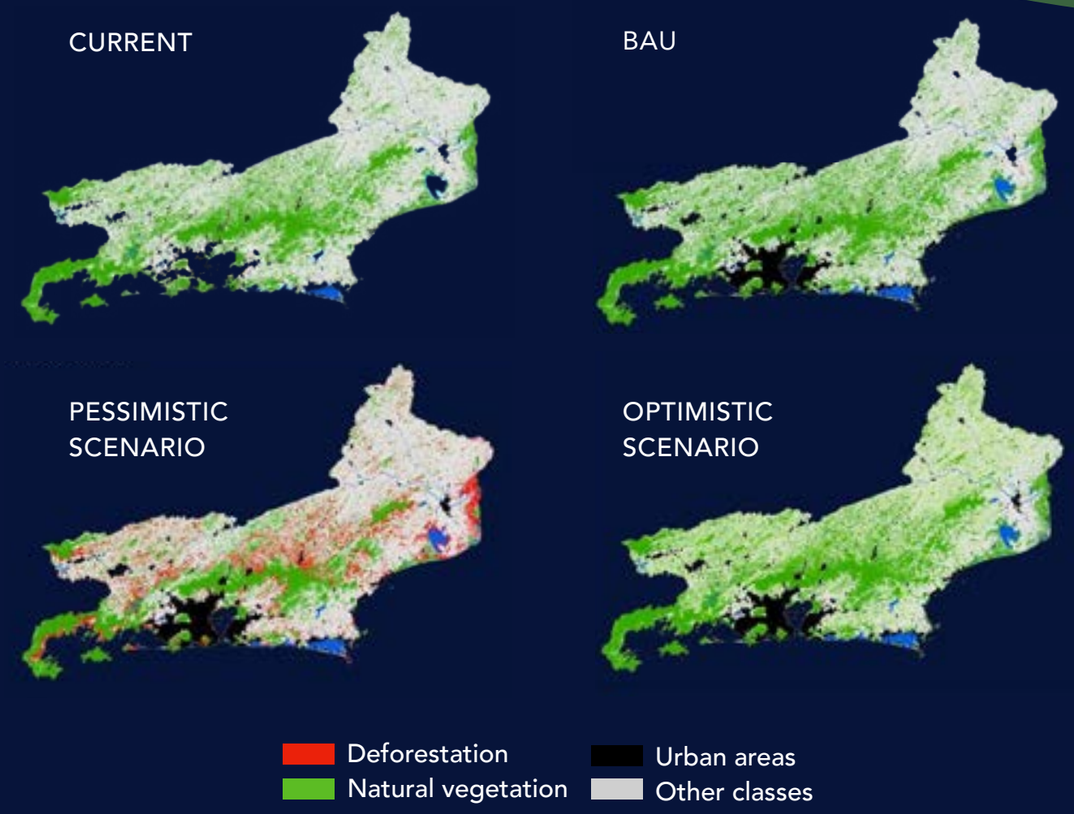
Step B – Definition of future scenarios

In Step B, different possible futures are projected based on trends identified in the previous step. Three narratives are developed: an optimistic one (with effective environmental policies), a pessimistic one (with increasing degradation), and a business-as-usual trend. These narratives are based on specific timeframes and may be qualitative or spatially explicit (represented by land-use maps and/or climate projections), depending on data availability.

In the case study of the state of RJ, for example, the timeframe was a projection for the year 2050.

APPLICATION IN RJ

In the state of RJ, the scenarios were based on IPCC guidelines and projected urban expansion and vegetation cover for 2050.
The optimistic scenario followed the state's reforestation targets.
The pessimistic scenario considered vegetation loss outside conservation units, permanent preservation areas (APP) and legal reserves.
The business-as-usual scenario reflected the continuation of patterns observed in recent years.



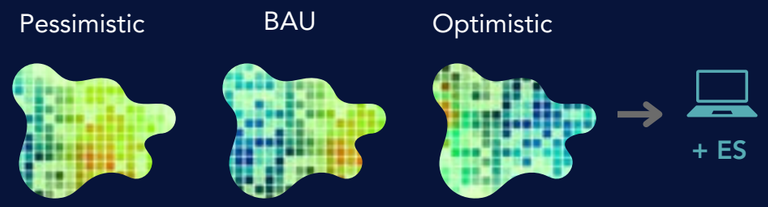
Land-use maps in the present and under the three future scenarios assessed in the state of RJ.

STEP C - ESTIMATING BES PROVISION

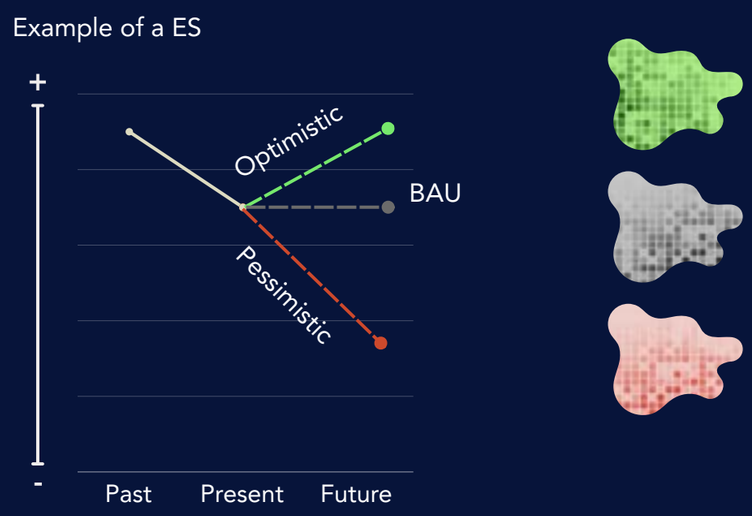
Estimating ES Provision

C

10 Modelling of ES for each scenario



11 Impacts of future scenarios on ES

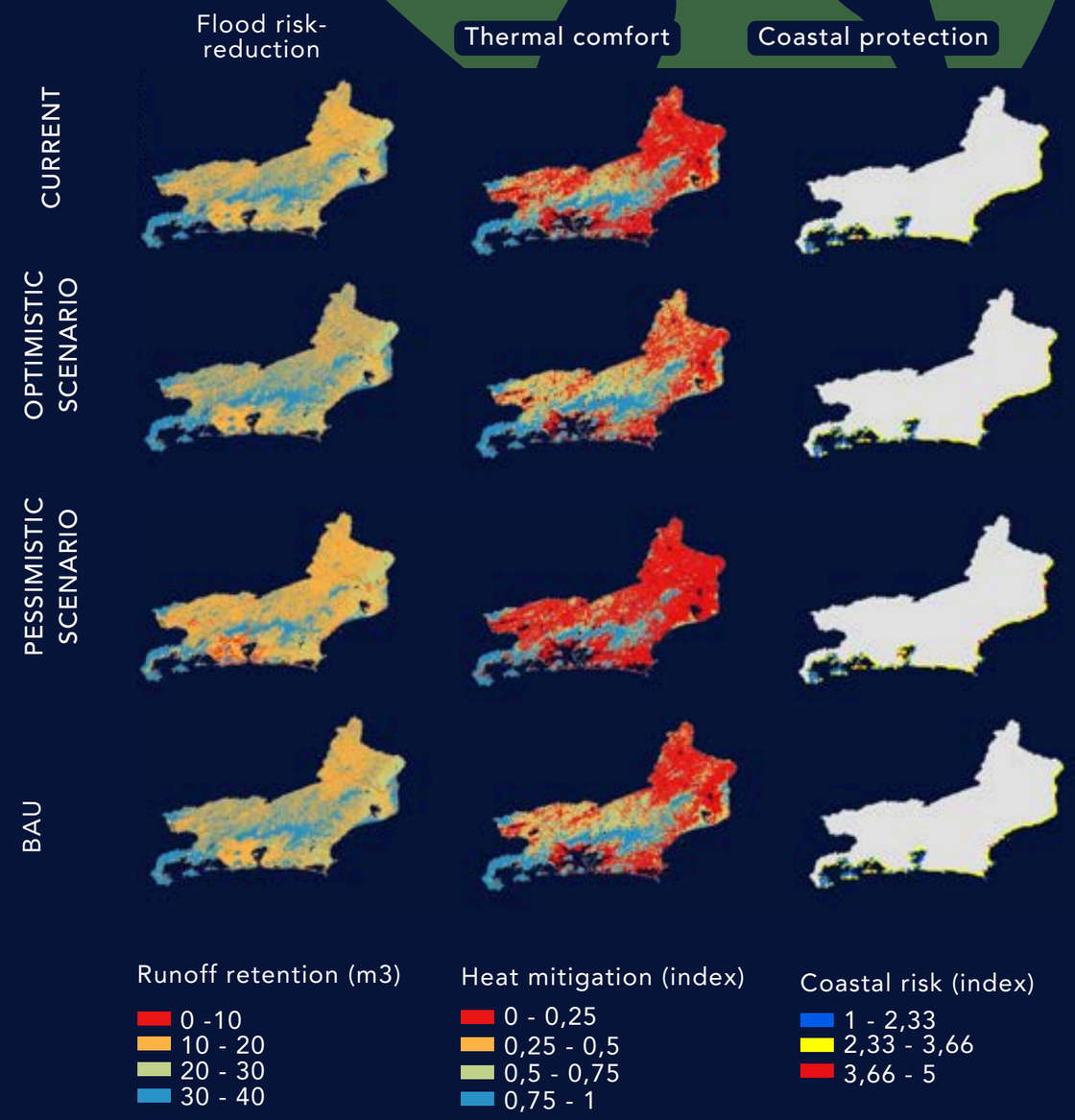


Step C – Estimation of ecosystem service provision in different future scenarios.

In Step C, the impacts of the scenarios developed in Step B on the ES selected in Step A are assessed. The estimation of ES is carried out individually for each scenario, and the results are compared. The aim is to identify areas with the greatest gains and losses in ES provision.

APPLICATION IN RJ

In RJ, the *InVEST* software was used to estimate ES provision in each scenario. The results indicated that, in the optimistic scenario, even restoring a small portion of the state (around 8%) would already deliver significant gains: thermal comfort would increase by 16%, flood control would improve by 6%, and high-risk coastal areas would be slightly reduced (by around 1%). On the other hand, in the pessimistic scenario, vegetation loss would lead to considerable reductions in these three ES.

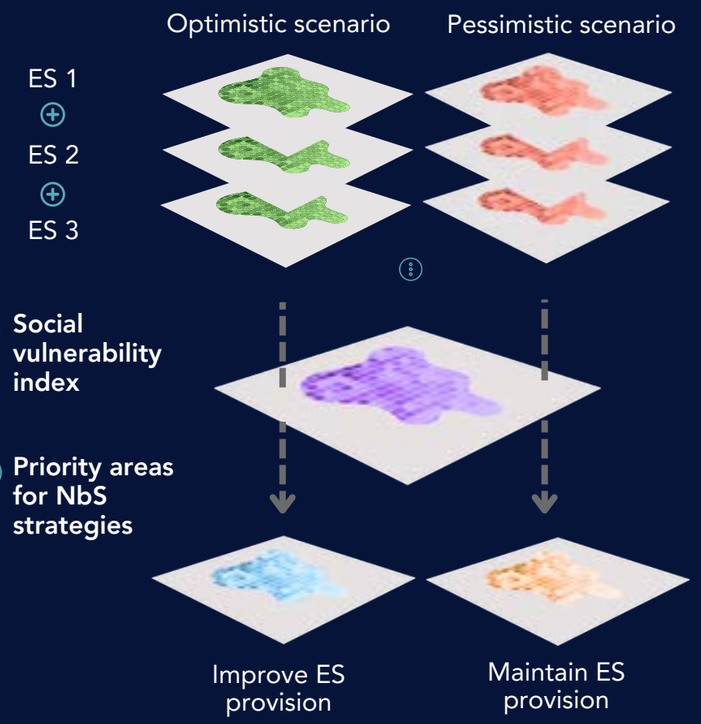


Impact of future scenarios on ES provision in the state of RJ.

Identifying Priority Areas for NbS

D

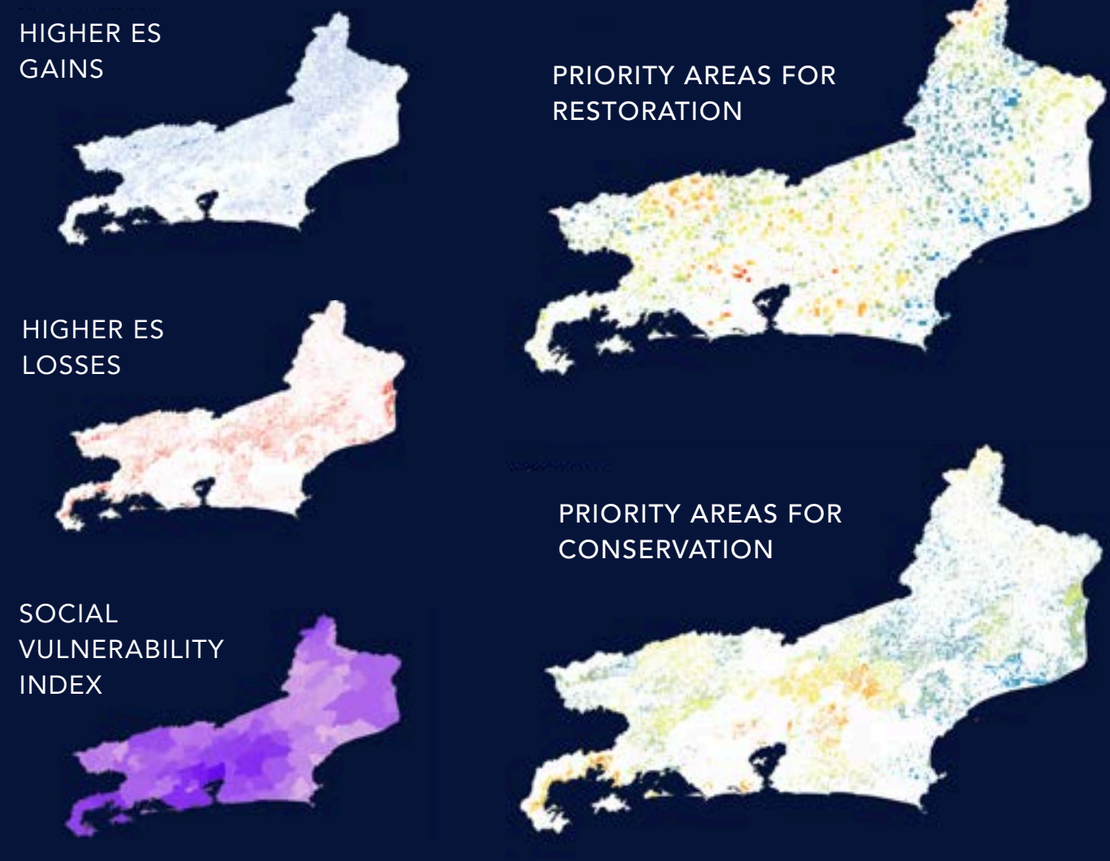
12 **ES higher gains and losses relative to BAU**



Step D – Identification of priority areas

In Step D, priority areas for the implementation of NbS are identified. These are represented by areas showing the greatest changes in ES provision, based on future scenarios of climate change and/or land use. Areas with greater future losses of ES (pessimistic scenarios) are strategic for conservation, in order to ensure that ES are not lost.
Meanwhile, areas with greater future gains of ES (optimistic scenarios) are important for restoration, with the aim of recovering ES that have already been compromised.
These results are further combined with social vulnerability indicators, which reflect socio-economic factors influencing a community's capacity to prepare for, cope with, and recover from environmental events. In this way, the priority areas are those most vulnerable, where NbS can deliver the greatest socio-environmental benefits.

APPLICATION IN RJ
In the state of RJ, the Municipal Vulnerability Index from the Oswaldo Cruz Institute (IOC/Fiocruz) and ES maps were used to rank the priority areas. These include regions with the greatest expected benefits from NbS and high vulnerability, such as the Metropolitan Region of RJ.



Sources:
SEA/INEA (2018) – Plano de Adaptação Climática do Estado do Rio de Janeiro (clima, riscos, impactos setoriais).
MapBiomas (2023) – Dados anuais de uso e cobertura da terra (resolução de 30 metros).
Índice de Vulnerabilidade Municipal (Instituto Oswaldo Cruz (IOC/Fiocruz).

Gains and losses of ES, social vulnerability, and priority areas for NbS in the state of RJ.

EXTRA STEPS

15 Quantifying costs and co-benefits

Stakeholder validation

Once the priority areas for NbS implementation have been defined, their costs and co-benefits (when applicable) should be estimated.

16 Informing decision-making

The results provide inputs for decision-makers at local, regional and national levels in the design and implementation of NbS for environmental disaster mitigation. The preparation of a communication plan is recommended to facilitate dissemination of the results and the engagement of different stakeholders.

APPLICATION IN RJ

Once the priority areas were identified in the state of RJ, the costs and co-benefits associated with NbS implementation were estimated. Conservation costs were calculated based on land opportunity cost, in Brazilian reais. Restoration costs were estimated considering both opportunity costs and implementation costs (the latter based on values established by the state of RJ for forest compensation).
Carbon stock: the potential carbon stock in the identified priority areas was calculated using models that account for climate conditions and different types of vegetation.
Biodiversity conservation: the contribution of priority areas to increased habitat availability for fauna and flora species was assessed, based on Species Distribution Models.

The results will be presented to and validated by representatives of the State Environment Institute (INEA), as well as other relevant institutions.

Co-benefits of NbS for the state of RJ.

FINAL CONSIDERATIONS

The application of the framework presented throughout this guide has demonstrated how Nature-based Solutions can guide strategies for environmental disaster mitigation. The work showed that, through the integrated analysis of future scenarios, ecosystem services and social vulnerability, it was possible to identify priority areas for these actions. The case study in the state of Rio de Janeiro provides practical evidence of the benefits of applying the framework. The modelling of future scenarios combined with social indicators enabled a more accurate analysis, capable of influencing effective environmental policies.
In an era of growing climate challenges and environmental degradation, strategic approaches to Nature-based Solutions are essential to maximise their effectiveness and impact. Our framework offers a science-based and adaptable methodology applicable to different contexts, balancing ecological benefits with social equity.