

## Framework for planning and evaluation of nature-based solutions for water in peri-urban

Ana Paula Morais de Lima<sup>2</sup>, Aline F. Rodrigues<sup>1,2</sup>, Agnieszka E. Latawiec<sup>1,2,3,4</sup>, Viviane Dib<sup>2,5</sup>, Fernanda Gomes<sup>2</sup>, Veronica Maioli<sup>1,2</sup>, Ingrid Pena<sup>1,2</sup>, Fernanda Tubenchlak<sup>2</sup>, Alanna J. Rebelo<sup>6</sup>, Karen J. Esler<sup>6</sup>, Amy M.P. Oen, Nancy Andrea Ramírez-Agudelo<sup>8</sup>, Elisabeth Roca Bosch<sup>8</sup>, Nandita Singh<sup>9</sup>, Lina Suleiman<sup>10</sup>, Sarah E. Hale<sup>7</sup>

- 1- Pontifical Catholic University of Rio de Janeiro, Department of Geography and Environment / Rio Conservation and Sustainability Science Centre, R. Marquês de São Vicente, 225 - Gávea, Rio de Janeiro - RJ, 22451-000, Brazil,
- 2- International Institute for Sustainability, R. Dona Castorina 124, 22460-320, Rio de Janeiro Brazil,
- 3- Department of Production Engineering, Logistics and Applied Computer Science, Faculty of Production and Power Engineering, Agricultural University Kraków, ul. Balicka 116b 30-149 Kraków, Poland
- 4- University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, United Kingdom
- 5- Federal University of Rio de Janeiro, Department of Ecology – Rio de Janeiro, Brazil
- 6- Department of Conservation Ecology & Entomology, Stellenbosch University, Private Bag x1, Matieland, 7602, South Africa
- 7- Norwegian Geotechnical Institute (NGI), P.O. Box 3930, Ullevål Stadion, N-0806 Oslo, Norway
- 8- Institute for Sustainability Science and Technology, Universitat Politècnica de Catalunya, Jordi Girona 1-3, 08034, Barcelona, Spain
- 9 -School of Natural Sciences, Technology and Environmental Studies, Södertörn University, Stockholm, Sweden
- 10-Lina Suleiman, Department of Urban Planning and Environment, School of Architecture and the Built Environment, KTH, Royal Institute of Technology, Stockholm, Sweden

### Supplementary material 1 (SM 1)

**Supplementary Material Table S1**| Systematic review spreadsheet

-File attached separately.

## Supplementary material 2 (SM 2)

Supplementary Material Table S2| Attributes table

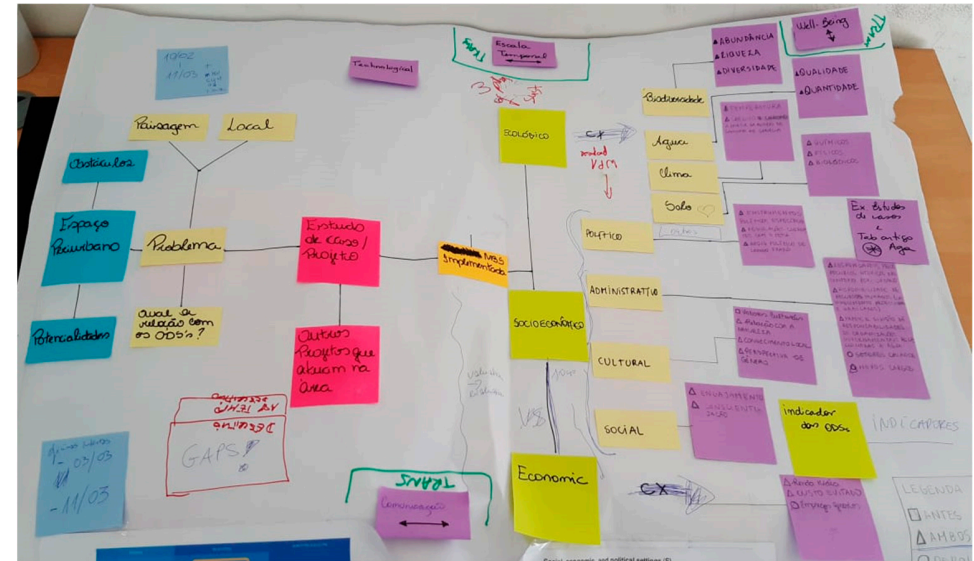
Attribute id	Attribute	Attribute type (# categories)	Attribute values	Description
1	Title	(text)		Title of the article.
2	Journal	(text)		Journal where the work was published.
3	Authors	(text)		Article authors.
4	Year of publication	(text)		Year the article was published.
5	Key-words	(text)		Article keywords chosen by the authors.
6	Article objective	(text)		Article objective as described in the publication.
7	Spatial context	Category (5)	Urban, Peri-urban, Rural, General Not clear/ Not applicable	Spatial context in which the framework should be applied, mentioned explicitly in the article.
8	Article approach	Category (3)	Conceptual, Practical Both	We consider 'conceptual' articles in which there is no application of the framework in a case study / experience. We consider 'practical' articles that present a case study / experience related to the application of the framework.
9	Challenge addressed	(text)		Challenges that NBS aims to overcome.
10	Words/concepts related to NBS	(text)		
11	Direct reference to SDG in the framework	Category (2)	Yes/No	Direct mention to SDGs. Include which SDG if cited.
12	Sustainability dimension addressed	Category (3)	EcologicalSocialEconomic	Whether the framewrok emphasizes NBS ecological, economic or social functions (NATWIP proposal, 2018). We consider it "ecological" when there is an emphasis on natural capital (examples: solar energy, earth materials, biogeochemical cycles, etc.). We consider it "social" when there is an emphasis on social and / or human capital (examples: health, wealth, leisure, mobility, education, gender equality, etc.). We consider it "economic" when there is an emphasis on economic development or avoided costs (examples: income increase and equality, job creation).
13	Assess approach of the framework (Qualitative or quantitative?)	Category (4)	Qualitative, Quantitative, Both Not clear/ Not applicable	Whether the framework assess / address qualitatively or quantitatively or both the benefits / issues.
14	Framework's purpose in relation to NBS	Category (4)	Planning, Evaluate, Both Not clear/ Not applicable	Whether the framework was designed for NBS planning and/or evaluation/assessment.

### Supplementary material 3 (SM 3)

**Supplementary Material Table S3** | The timeline of the meetings and workshops as well as steps in the framework construction process.

DATE	THEME ADDRESSED/AGENDA
09/01/2020	International meeting - Discussion about the NBS definition adopted and its' reflections on framework construction .
30/01/2020	International meeting- Discussion about existing frameworks and the gaps that the framework could fill.
07/02/2020	International meeting- Discussion about the peri-urban concepts and differences according to the local needs and the necessity to construct a flexible scheme adaptable to different contexts.
03/03/2020	1°Workshop of framework construction design.
10/03/2020	2°Workshop of framework construction design.
11/03/2020	3°Workshop of framework construction design.
31/03/2020	International Meeting- Analysis of the first draft of the framework and organization of the next steps to refine the scheme.
09/04/2020	Internal Meeting- Discussion about the indicators related to the framework.
14/04/2020	Internal Meeting- Discussion about the indicators related to the framework.
15/04/2020	International Meeting- Consultation about indicators classification.
23/04/2020	Meeting with graphic designer to elaborate the framework images.
06/05/2020	Meeting with a Brazilian expert on NBS implementation- Discussion about indicators used on the project “Water and Forest Producer”
27/05/2020	Internal Meeting- Adjustments and organization of the indicators table.
04/06/2020	Meeting between Brazilian and Spanish experts- Discussion about the NBS literature review and NBS framework.
08/06/2020	Meeting between Brazilian and England experts. Discussion about the changes adopted to the framework and indicators table.
16/06/2020	Meeting with graphic designer to discuss adjustments to the framework images
17/06/2020	Meeting with Brazilian experts - Classification of the indicators suggested as process and result indicators.
29/06/2020	Meeting with Brazilian experts - Final adjustment of the indicators organization according to the categories.
30/06/2020	Meeting with Brazilian experts - Alignment between the indicators organization and the framework categories and dimensions.
02/02/2020	Meeting between international experts- Final consultation of refined framework and indicators classification/organization.

## Supplementary Material Figures S1–S2 | Workshop of framework construction design.



## Supplementary material 5 (SM 5)

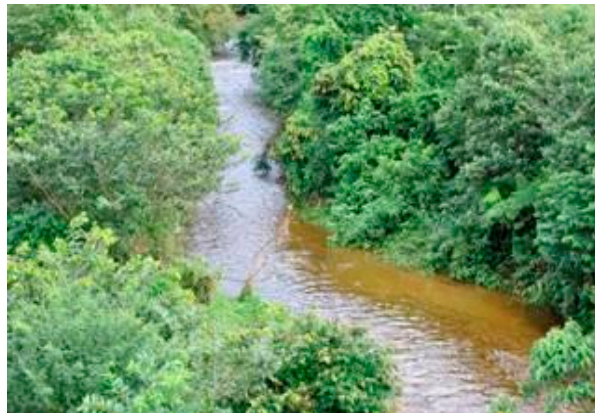
### Supplementary Material Description and Figures S3–S5 | Water and Forest Producer Project

The Water and Forest producer project is a payment for environmental services project in a peri-urban area in Rio de Janeiro, Brazil. In this project, rural producers receive money as an incentive to restore and conserve forest areas on their properties. This restoration aims to improve the quality and quantity of water. These actions have been implemented in a basin responsible for providing water to more than 7 million people.

The following links provide more information about the project:

[http://www.itpa.org.br/wp-content/uploads/PSA\\_da\\_Teoria\\_a\\_Pratica\\_MauricioRuiz\\_ITPA-1.pdf](http://www.itpa.org.br/wp-content/uploads/PSA_da_Teoria_a_Pratica_MauricioRuiz_ITPA-1.pdf)

[http://www.itpa.org.br/?page\\_id=497](http://www.itpa.org.br/?page_id=497)



**Riparian Forest Restoration at Papudos River**



**Producers receiving payment**



**Preparation for Forest Restoration**

## Supplementary material 6 (SM 6)

**Supplementary Material Table S4-1** | Table of qualitative information (Context assessment).

INFORMATION REQUIRED	SPECIFICATION	EXAMPLES
Location	Continent	
	Country	
	City	
Type		Urban, peri-urban, rural...
Threats		Lack of legislation, absence from the state...
Opportunities		Labor, participatory community ...
Challenge		Floods/Drought/Water supply/Climate changes/ Society's
Pressure	Local Scale	Drug trafficking, real estate speculation, water pollution ...
	Landscape Scale	
Actors identification		List of institutions in the area related to the target (local or regional government/ Civil society/ Academia/ Industry/ Other)
SDGs association		Goals number
OTHER PROJECT IN PLACE		

**Supplementary Material Table S4-2** | Table of indicators (process)

Project/Case	Qualitative Information	Information Recquired		Example
		Actors Involved		List of institutions in the area related to the NBS (local or regional government/ Civil society/ Academia/ Industry/ landowners/ Other)
		NBS Scale		Local, regional, national...
		NBS Type		Restoration, river park, biowasle, green roof...
	Process Indicators	Dimension	Category	Input/ Output Indicators
		Environmental	Interventions	Number of trees seedlings planted
				Number of green roofs implemented
				Number of roads recovered
				Area that received the green and blue infrastructure
				Rate of trees seedlings planted survival
				Other
		Social	Project Management	Availability of human resources
			Political Support	Number of people participating in the NBS project
Number of laws and policies developed or reformed				
Cultural/ Awerness or Educational			Long term political support	
Commitment			Incorporation of cultural values and perceptions	
	Continuous participation in the NbS Process (level of participation in each cycle phase)			
Other				
Economic	Income and Jobs	Number of jobs created directlty		
		Number of income generating activities (IGA) created		
Household Income				

## Supplementary Material Table

### S4-3 | Table of indicators (results)

LEVELS/ STAGE	DIMENSIONS	CATEGORY	OUTCOMES/ IMPACTS INDICATORS
NBS RESULTS (outcomes and impacts)	Social	Cultural	Valorization of natural resoucers visitation of natural/green spaces
		Politics and governance	development of new policies related to NBS Improvements/adjustments to existing policy instruments
		Water Provisioning services	Water Depth Water Table Level Number of springs StreamFlow
	Environmental	Water Regulation and maintenance services	Turbidity
			Dissolved oxygen cocentration
			Nutrient (N, P) concentration
			Cyanobacteria bloom events
			Biochemical Oxygen Demand (BOD)
			Total coliforms
			Total nitrogen
			nitrate
			Nitrite
			Ammoniacal nitrogen
			Dissolved inorganic phosphate (PID)
			Total dissolved phosphates (PTD)
			Heavy metals
			Pesticides
			Dissolved organic carbon (DOC)
			Dissolved inorganic carbon (DIC)
			pH
			Cations (sodium, calcium, potassium, magnesium)
			Anions (carbonates, bicarbonates, chlorides, sulfates,
			Total hardness
			Chlorophyll
			Oils and greases
			Salinity
			Alkalinity
			Other
		Soil Regulation and Maintenance	Soil Permeability Erosion prevention
		Biodiversity Conservation	Diversity Index
			Composition (aquatic and terrestrial species)
			Presence of bioindicators species (fauna and flora)
			Habitat Conectivity
			Aquatic diversity index
			Aquatic species richness
			Percentage of cover native vegetation
		Socio-Cultural services	Benthic organisms
			Percentage of Invasive exotic vegetation
			Recreational uses
			Aesthetic improvement
			Social/cultural values for ecoystems and biodiversity
			Spiritual, symbolic and other interactions with natural environment
			Tourism (aquatic, farm, Forest)
	Economic	Income and Jobs	Number of income generating activities (IGA) created indirectly
			Number of jobs created indirectly
			Land Price
			Property betterment
		Avoided Costs	Water treatment costs Fertilizers costs



## Supplementary Material 7 (SM7)

### Supplementary Material SM7 | Planning Cycle phases definitions

Planning cycle phases	Definitions
Research and development	An activity that depends on a specific question or objective. It could be R&D to test out solutions in the lab/meso or pilot scale or it could be desk work investigating the site to implement a possible NBS.
Planning	This is a more general term and is related to the planning that is needed for the intervention. It encompasses desktop studies, and preliminary investigations to assess a potential intervention(s). It can also include the involvement of stakeholders to check the suggested NBS is viable at the site (feasibility study). It may include a prediction of the expected expenses and the planning of actions for the NBS implementation.
Conceptual design	This is the moment when the urban planners, landscape architects and engineers (among others) with relevant backgrounds make the overarching design of the NBS. This moves the NBS from what is viable to a specific solution (conceptual).
Detailed design	The actual design of the intervention (engineering calculations, models completed) which is most often communicated as technical drawings that can be directly used for the construction of the intervention.
Construction	The physical construction of the NBS by those including construction companies, NGOs and local people at the project site.
Monitoring	The process of collecting and analyzing data and information aiming to identify changes in relation to a baseline.
Evaluation	The process of examining the monitoring data to identify the influences/impacts of the project activities and summarize lessons learned.
Adjustments	The process of adjusting project activities to improve results.