Porto Alegre, 16 out 2025

Soluções baseadas na Natureza: Conceitos e Aplicações sobre suas Multifuncionalidades e Co-benefícios

FERNANDO MAGALHÃES

INCT SbN

UFRGS UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

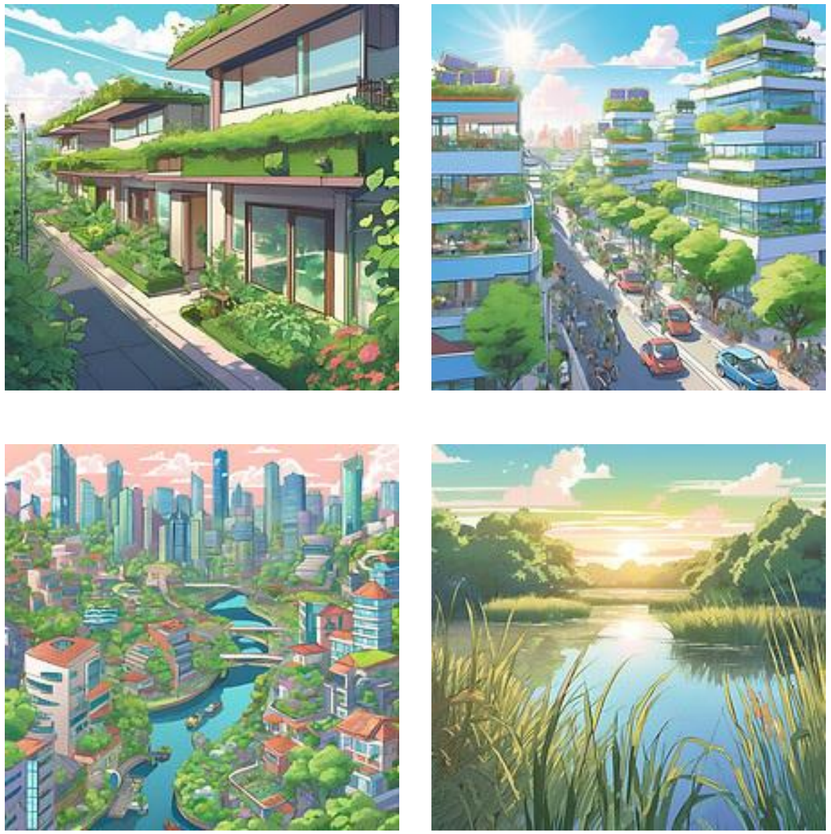
1896 ESCOLA DE ENGENHARIA UFRGS

CONCEITOS e histórico

Programa das Nações Unidas para o Ambiente (UNEP, 2022)

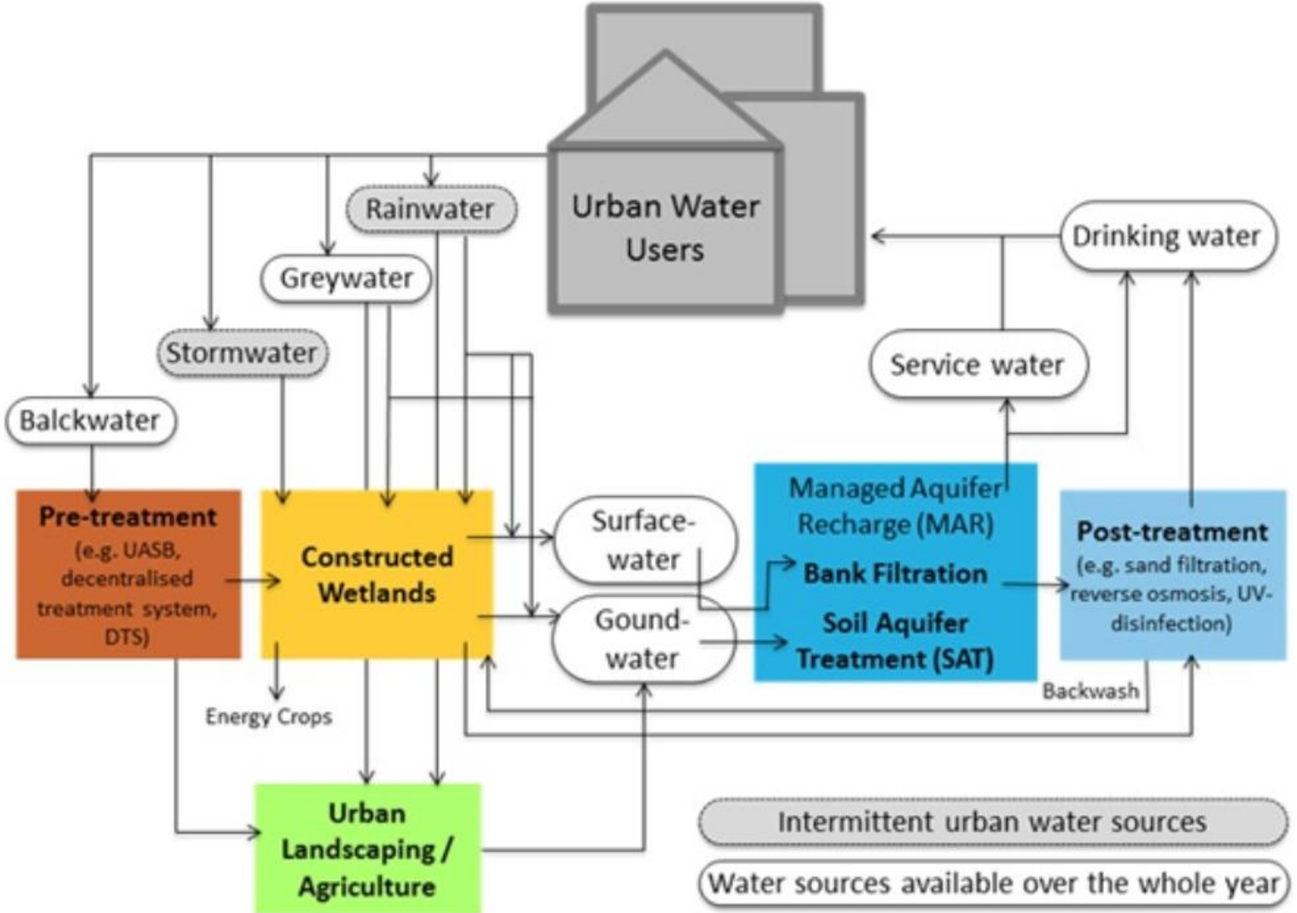
- “ações para **proteger, conservar, restaurar**,
- visando o **manejo sustentável de recursos** naturais ou modificados dos **ecossistemas** terrestres, de água doce, costeiros e marinhos,
- que também abordam **desafios sociais, econômicos e ambientais** de forma **eficaz e adaptável**, ao mesmo tempo em que promove **bem-estar** humano, **serviços ecossistêmicos**, **resiliência** e benefícios para a **biodiversidade**.”

O que é? Um breve histórico



Fonte: INCT SbN.

NaWaTech
Compendium of Natural Water Systems and Treatment Technologies to cope with Water Shortages in Urbanised Areas in India
Co-funded by the Seventh Framework Programme of the European Union and the Indian Department of Science and Technology


Urban Water Users
Rainwater
Greywater
Stormwater
Balckwater
Drinking water
Service water
Pre-treatment (e.g. UASB, decentralised treatment system, DTS)
Constructed Wetlands
Surface-water
Gound-water
Managed Aquifer Recharge (MAR)
Bank Filtration
Soil Aquifer Treatment (SAT)
Post-treatment (e.g. sand filtration, reverse osmosis, UV-disinfection)
Backwash
Energy Crops
Urban Landscaping / Agriculture
Intermittent urban water sources
Water sources available over the whole year

Blue-Green Systems

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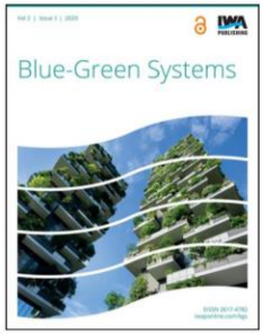
Volume 2, Issue 1
1 January 2020



RESEARCH ARTICLE | FEBRUARY 03 2020

A review of nature-based solutions for resource recovery in cities

Johannes Kisser; Maria Wirth; Bart De Gusseme; Miriam Van Eekert; Grietje Zeeman; Andreas Schoenborn; Björn Vinnerås; David C. Finger; Sabina Kolbl Repinc; Tjaša Griessler Bulc
Aida Bani; Dolja Pavlova; Lucian C. Staicu; Merve Atasoy; Zeynep Cetecioglu; Marika Kokko; Berat Z. Haznedaroglu; Joachim Hansen; Darja Istenič; Eriona Canga; Simos Malamis; Margaret Camilleri-Fenech; Luke Beesley

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Blue-Green Systems (2020) 2 (1): 138–172.
https://doi.org/10.2166/bgs.2020.930 **Article history**

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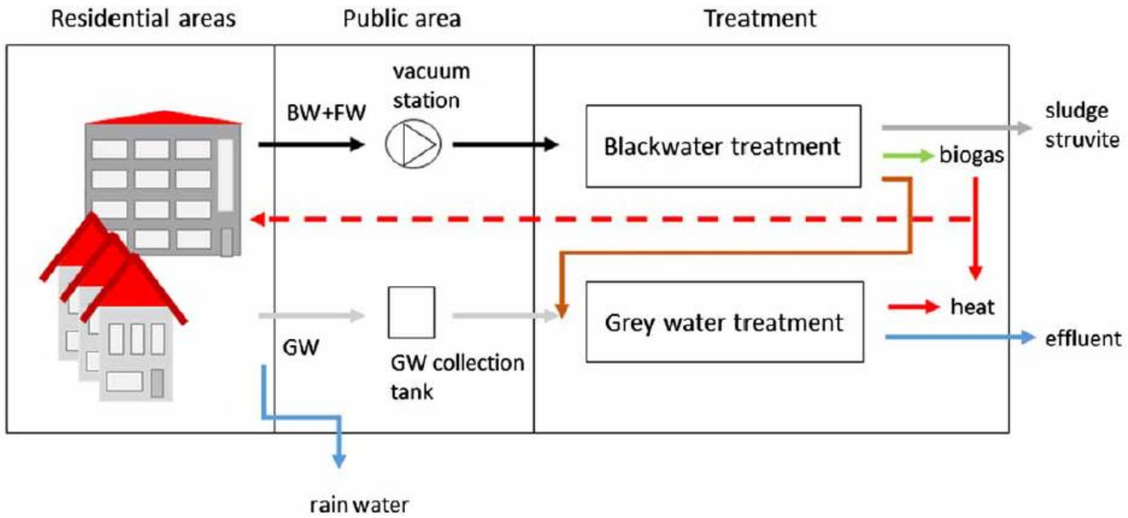


Figure 3 | Schematic representation of the projects in Sneek, the Netherlands (redrawn and adapted from Wit *et al.* 2018).

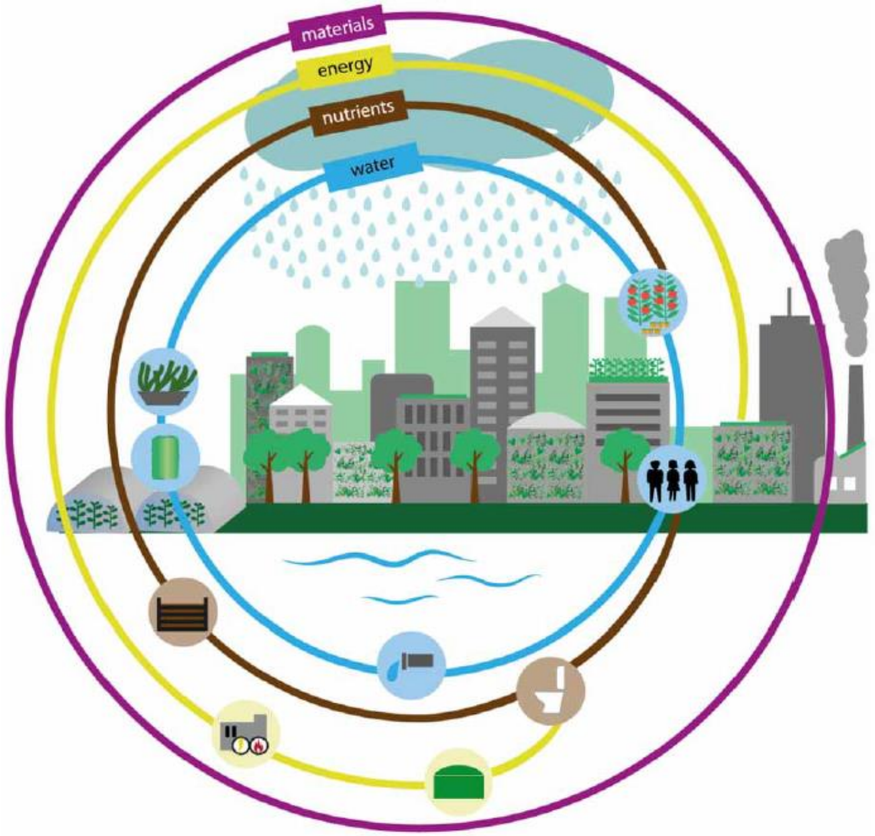


Figure 1 | Overview of urban water, nutrient, material and energy loops enabled using NBS within cities.

Science of the Total Environment 779 (2021) 146237

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Nature-based solutions in the urban context: terminology, classification and scoring for urban challenges and ecosystem services

J.A.C. Castellar [a,b,*], L.A. Popartan [c], J. Pueyo-Ros [a,b], N. Atanasova [d], G. Langergraber [e], I. Säumel [f], L. Corominas [a,b], J. Comas [a,c], V. Acuña [a,b]

[a] Catalan Institute for Water Research (ICRA), Carrer Emili Grahit 101, 17003 Girona, Spain
[b] University of Girona, Plaça de Sant Domènec 3, 17004 Girona, Spain
[c] LEQUIA. Institute of the Environment, University of Girona Campus Montilivi, carrer Aurèlia Capmany, 69 E-17003 Girona, Catalonia, Spain
[d] University of Ljubljana, Faculty of Civil and Geodetic Engineering, Jamova 2, 1000 Ljubljana, Slovenia
[e] Institute of Sanitary Engineering and Water Pollution Control, University of Natural Resources and Life Sciences, Vienna (BOKU), Muthgasse 18, A-1190 Vienna, Austria
[f] Integrative Research Institute on Transformations of Human-Environment Systems (IRI THESys), Humboldt Universität zu Berlin, Unter den Linden 6, D-10099 Berlin, Germany

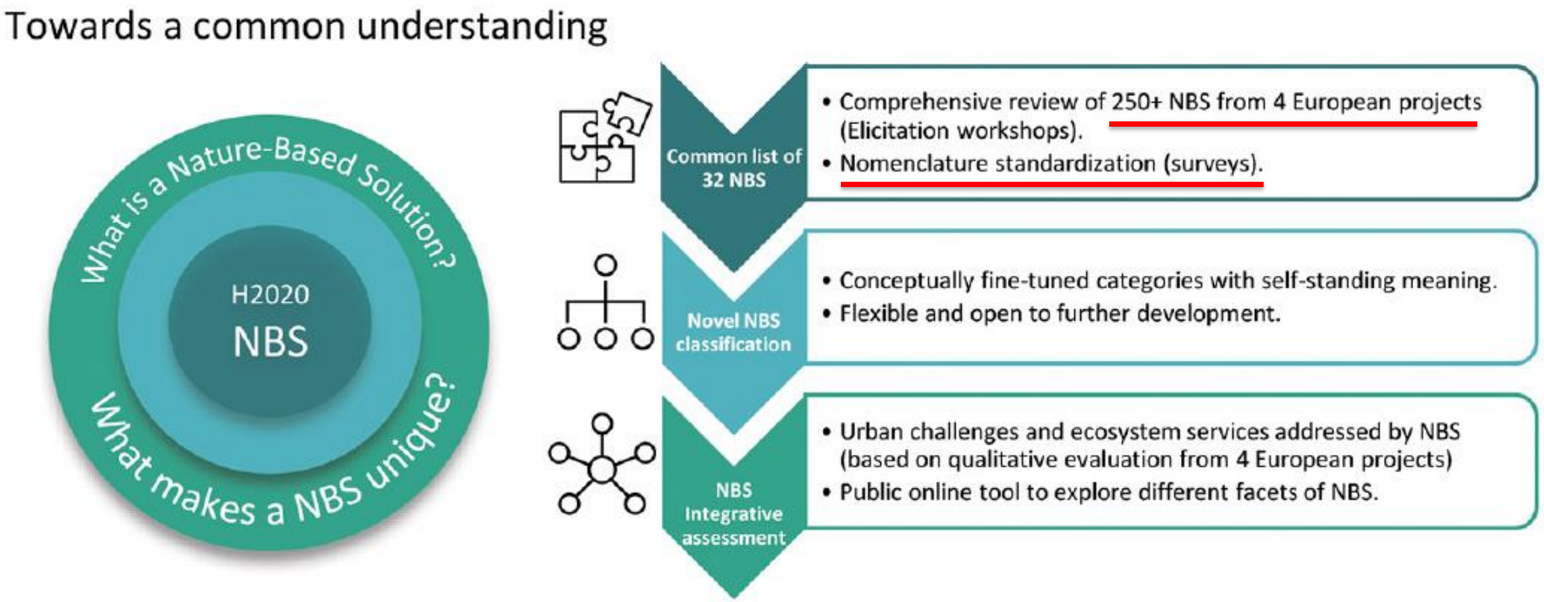
https://doi.org/10.1016/j.scitotenv.2021.146237

COST Action
"Circular City"
https://www.cost.eu/

HIGHLIGHTS

- *Motivation:* A Lack of a common conceptualization of Nature-Based Solutions (NBS)
- *Methodology:* Mixed quantitative-qualitative to merge results from 4 European projects
- *Outcomes:* A list of 32 NBS, a nomenclature, a novel classification and assessment
- *Key findings:* The 'green factor' and non-intensive actions are key criteria for identifying a solution as an NBS.
- *Further research:* Discerning NBS and planning approaches

GRAPHICAL ABSTRACT



https://ec.europa.eu/programmes/horizon2020/

NBS units (NBSu) that are **stand-alone green technologies** or **green urban spaces**, which **can be combined with other solutions** (nature-based or not);

NBS interventions (NBSi) that refer to the **act of intervening in existing ecosystems and in NBSu**, by applying **techniques to support natural processes**.

Table 1
Common list of NBS and respective grouped/paired NBS (considered similar or equal across projects).

NBS	NBS (grouped or paired)			
	GU	UNL	N4C	TN
NBS1	Floodable park	Infiltration basin; (Dry) Detention Pond		
NBS2	Grassed swales and water retention ponds	(Wet) Retention Pond		
NBS3	Rain gardens	Rain gardens		
NBS4	Grassed swales and water retention ponds	Bioswale	Swale	
NBS5	Electro Wetland	Constructed wetlands	Constructed wetland for wastewater treatment	Use engineered reedbeds/wetlands for tertiary treatment of effluent
NBS6	Green façade with climbing plants	Noise barrier as ground-based greening; Ground-based greening	Climber green wall	Climber green wall
NBS7	Hydroponic green façade; Green noise barriers	Façade-bound greening	Green wall system	Green wall system
NBS8	Vertical mobile garden	Mobile vertical greening / Mobile Green living Room		
NBS9			Planter green wall	Planter green wall
NBS10	Green shady structures		Vegetated pergola	
NBS11	Green roof; Green covering shelters	Extensive green roof; Constructed wet roof	Extensive green roof	Intensive green roof/Semi-intensive green roof/Extensive green roof
NBS12	Green roof	Intensive green roof	Intensive green roof	Intensive green roof/Semi-intensive green roof/Extensive green roof
NBS13		Smart roof	Semi-intensive green roof	Intensive green roof/Semi-intensive green roof/Extensive green roof
NBS14	Natural pollinator's modules; Compacted pollinator's modules		Create and preserve habitats and shelters for biodiversity	Create and preserve habitats and shelters for biodiversity
NBS15	Planting and renewal urban trees; Trees re-naturing parking	Single line trees; Boulevards	Street trees; Single tree	Street trees
NBS16		Green Corridors		Green corridors and belts
NBS17	Green resting areas	Residential park	Large urban public park	Large urban park
NBS18	Green resting areas; Parklets		Pocket garden/park	Pocket garden/park
NBS19	Arboreal areas around urban areas	Group of trees	Wood; Urban forest	Urban forest
NBS20			Heritage garden	Heritage park
NBS21			Private gardens	Private gardens
NBS22			Vegetables gardens	Community garden; Vegetable gardens
NBS23	Urban orchards		Urban orchard	Urban orchards
NBS24			Use of pre-existing vegetation	Use of pre-existing vegetation
NBS25	Community composting		Composting	
NBS26	Enhanced nutrient managing and releasing soil; Smart soil as substrate		Soil improvement; Structural soil; Mulching	Soil improvement and conservation measures; Incorporating manure, compost, biosolids, or incorporating crop residues to enhance carbon storage
NBS27			Soil & slope revegetation; Strong slope vegetation	Systems for erosion control
NBS28		Living fascine; Living revetment; Revetment with cuttings (Spreitlage); Planted embankment mat	Vegetation engineering systems for riverbank erosion control	Systems for erosion control
NBS29	Hard drainage-flood prevention Unearth water courses	Reprofiling the channel cross-section; Channel widening and length extension; Daylighting	Reopened stream	Rivers or streams, including re-meandering, re-opening Blue corridors; Systems for erosion control
NBS30		Branches; Reprofiling/Extending flood plain area	Floodplain	
NBS31	Hard drainage-flood prevention Unearth water courses	Diverting and deflecting elements		Systems for erosion control
NBS32	Green parking pavements; Cycle-pedestrian green pavement	Vegetated grid pave	Green parking lot	

URBANGREENUP (GU)

UNALAB (UNL)

NATURE4CITIES (N4C)

THINKNATURE (TN)

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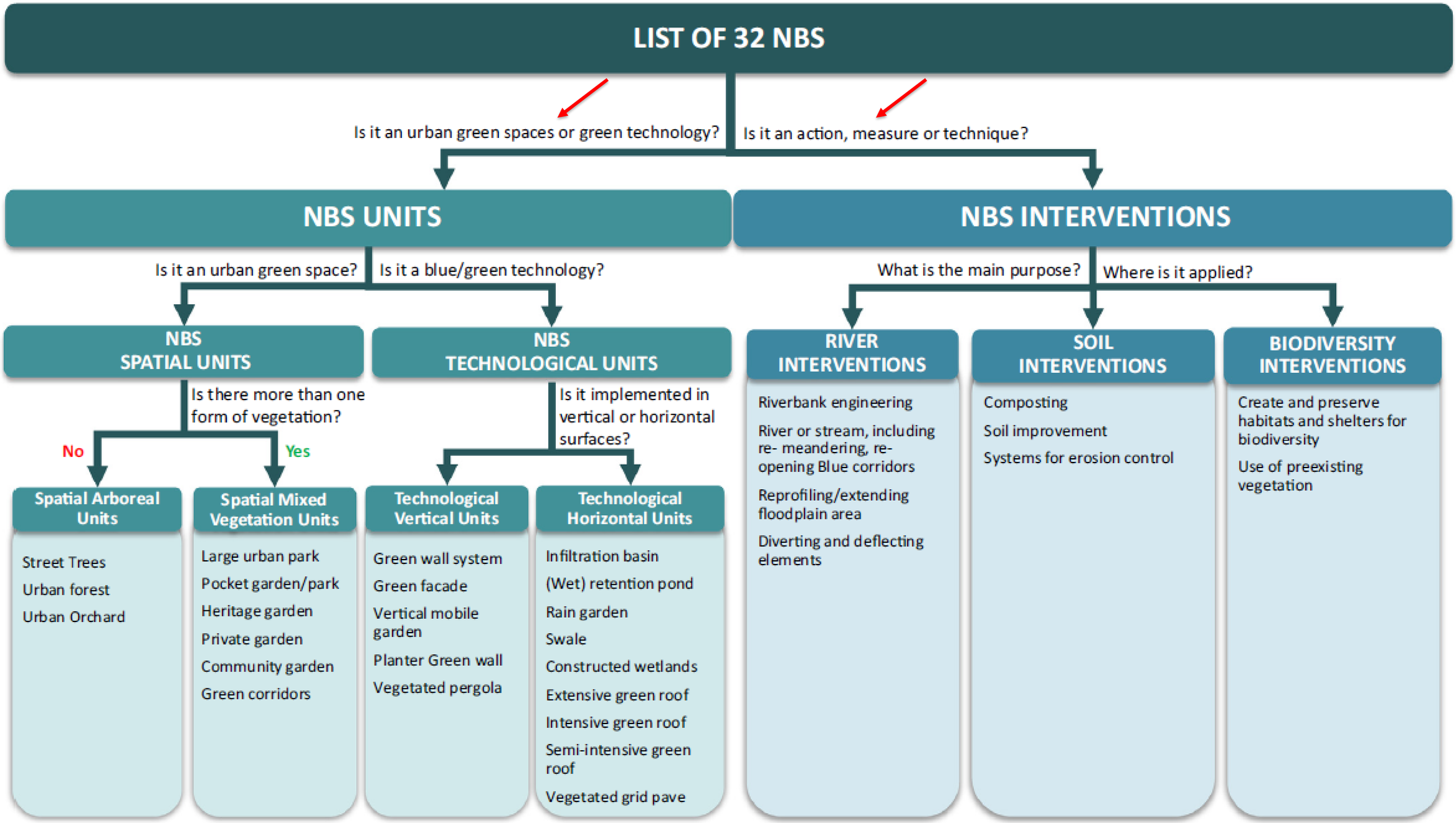


Fig. 2. A novel hierarchical classification of considered NBS.

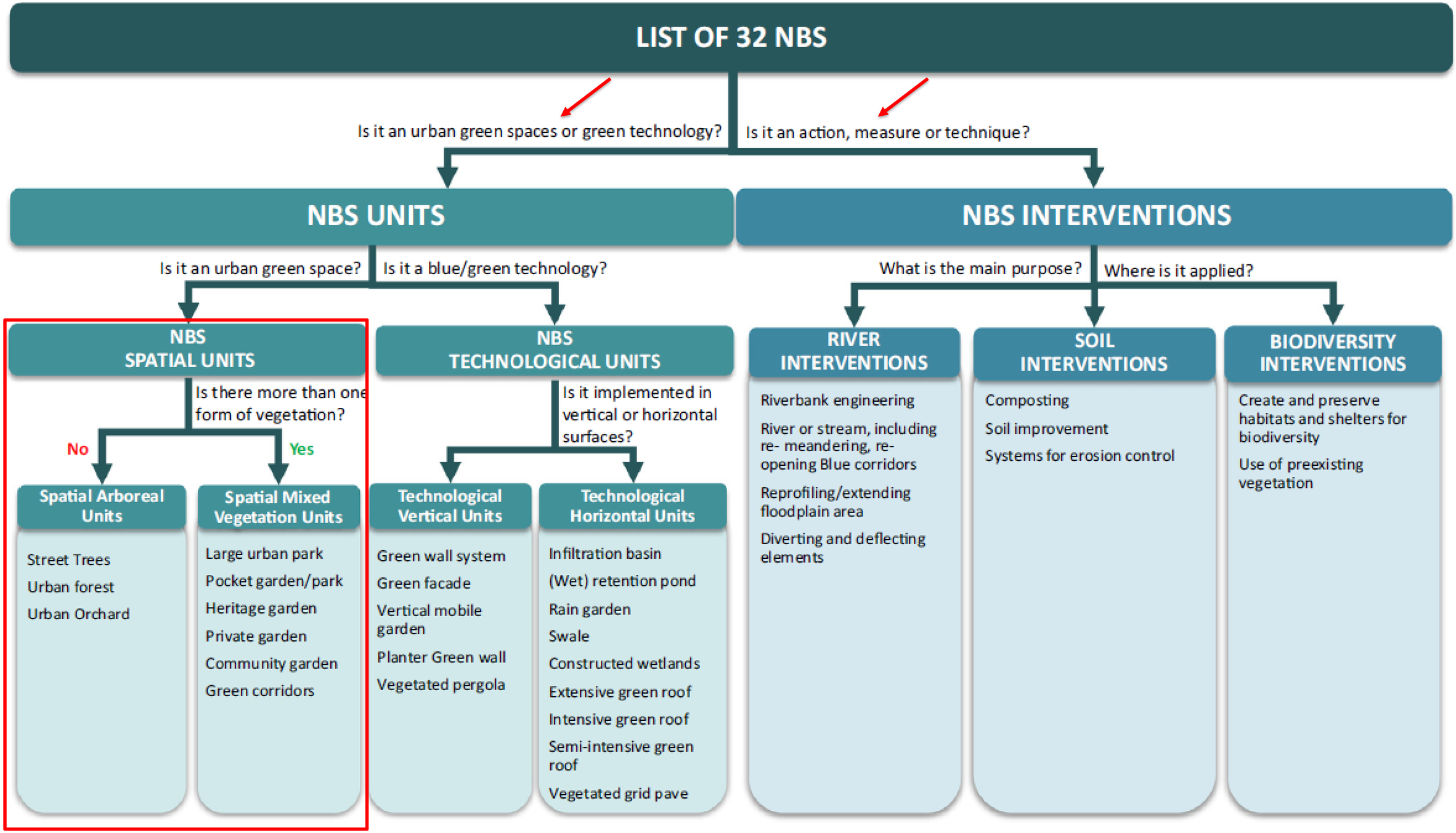
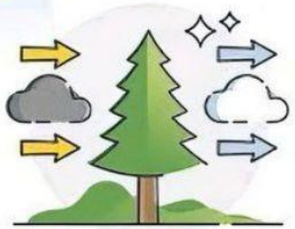


Fig. 2. A novel hierarchical classification of considered NBS.

Arborização urbana

Reduz a temperatura

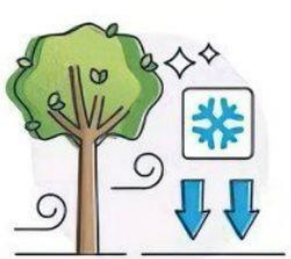
Regula o fluxo de água e sua qualidade



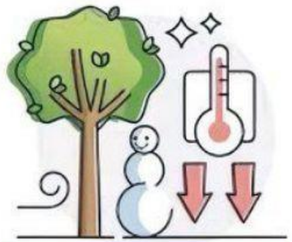
Filtra a poluição

Contribuí p/ a mitigação das mudanças climáticas

Melhora as saúdes física e mental das pessoas



Reduz a dependência de ar-condicionado



Reduz o consumo de energia

Aumenta a biodiversidade urbana

Valoriza propriedades

communications earth & environment

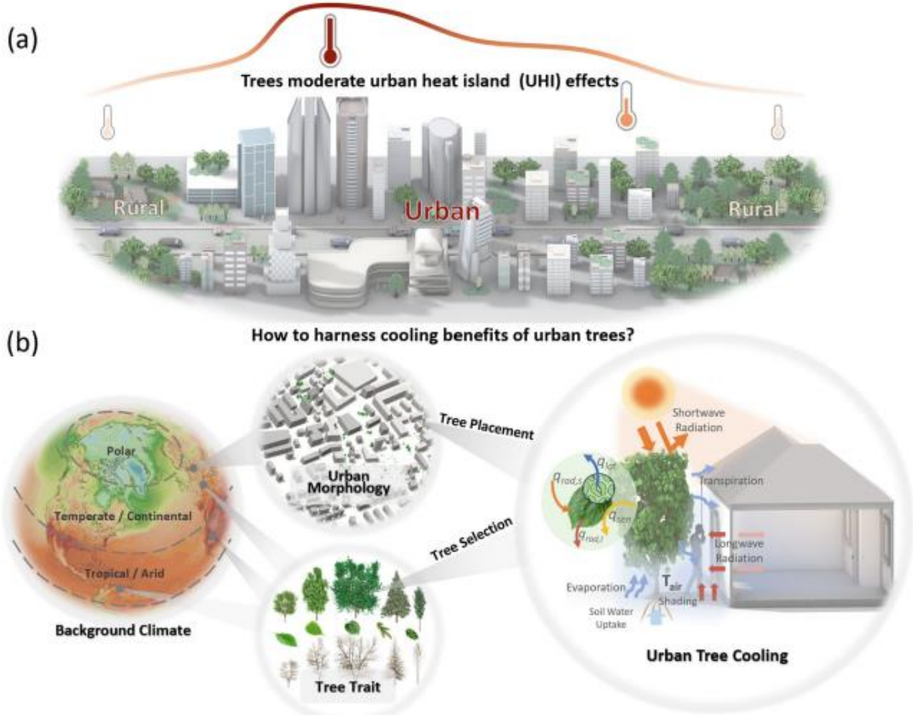
Article

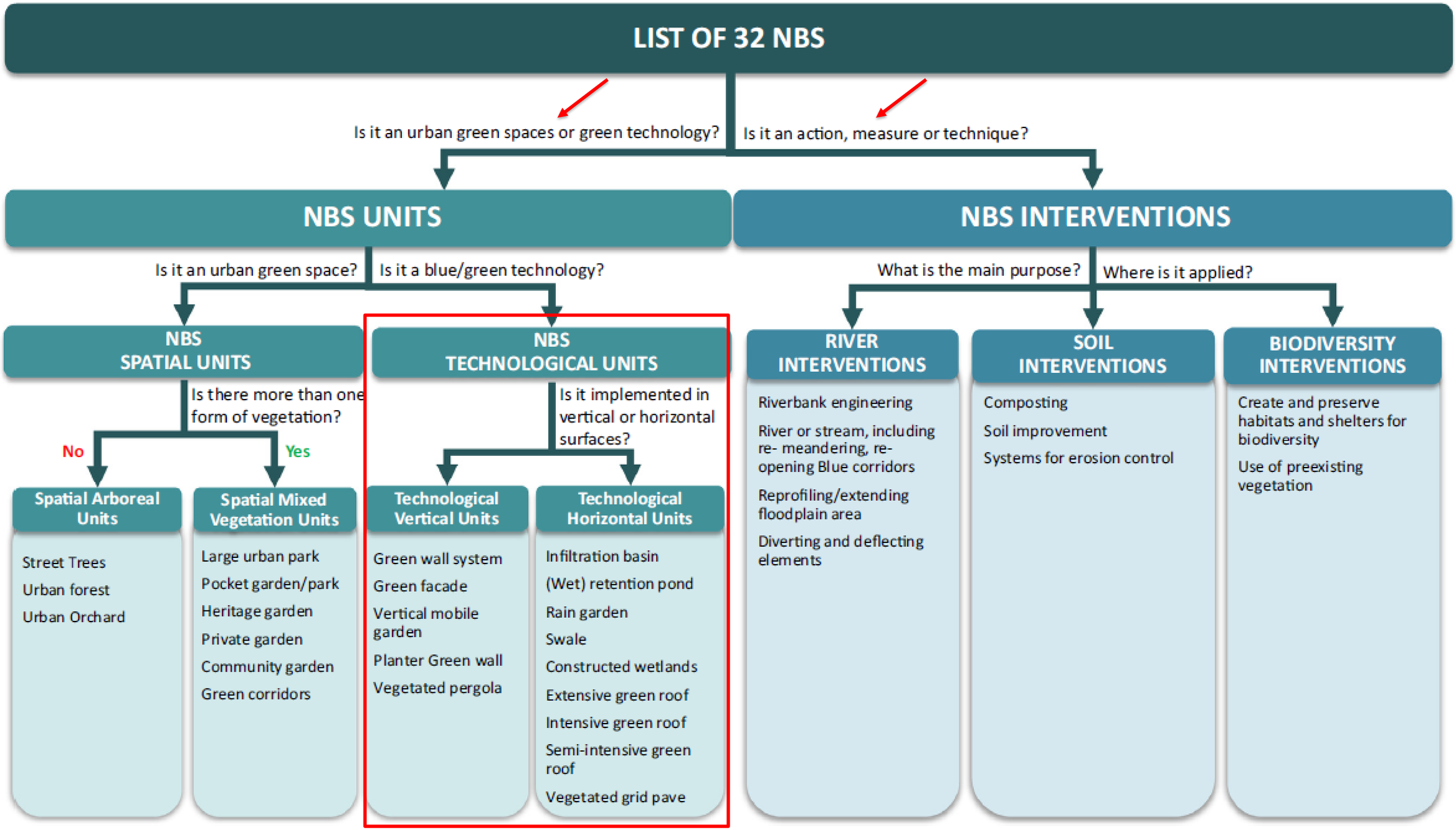
https://doi.org/10.1038/s43247-024-01908-4

Cooling efficacy of trees across cities is determined by background climate, urban morphology, and tree trait

Check for updates

Haiwei Li[1,2], Yongling Zhao[2], Chenghao Wang[3], Diana Ürge-Vorsatz[4], Jan Carmeliet[2] & Ronita Bardhan[1]





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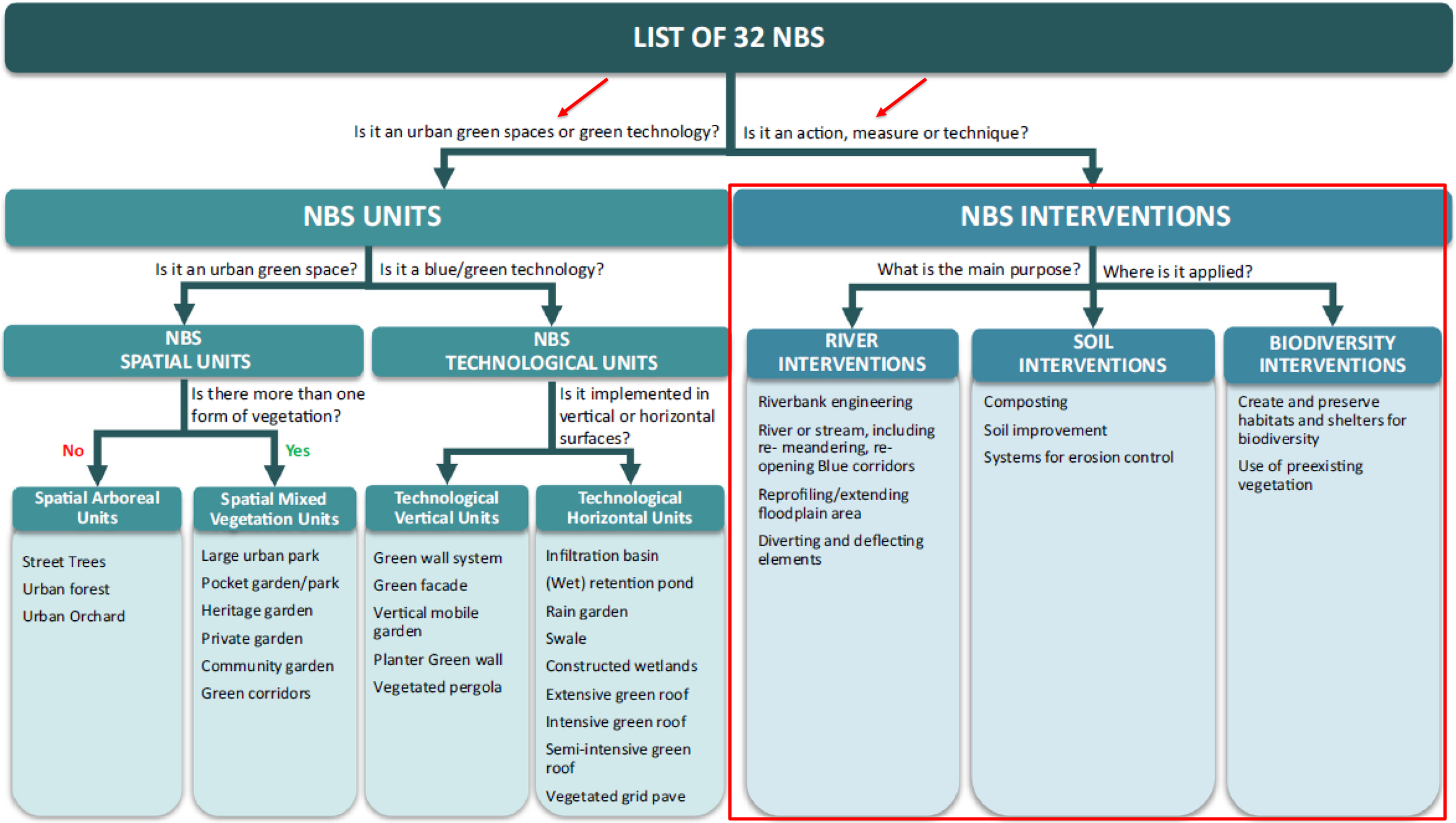


Fig. 2. A novel hierarchical classification of considered NBS.

Rio Cheon Gye Cheon
Seul/Coréia do Sul

Rio San Antonio
Texas/EUA

Rio San Antonio
Texas/EUA

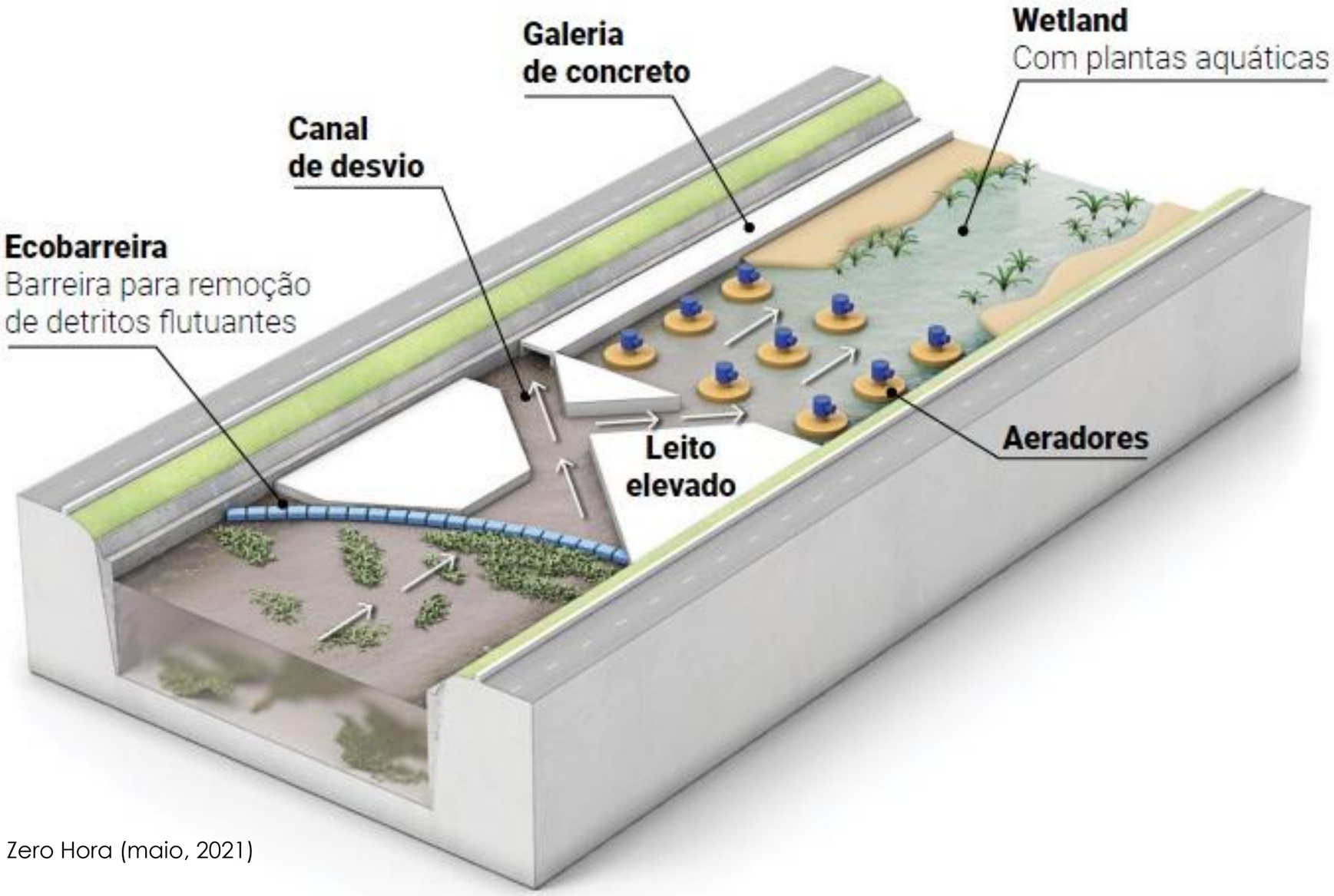
Rio Chicago
Chicago/EUA

Rio Li-Chuang

Li-Chuang/Taiwan

Rio Yangtzé
Zhangjiagang/China

Tipo 1) Contato secundário e vazão controlada: trechos em módulos



Zero Hora (maio, 2021)

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SISTEMA DE AERAÇÃO

+

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(Dentro da calha do Arroio Dilúvio)

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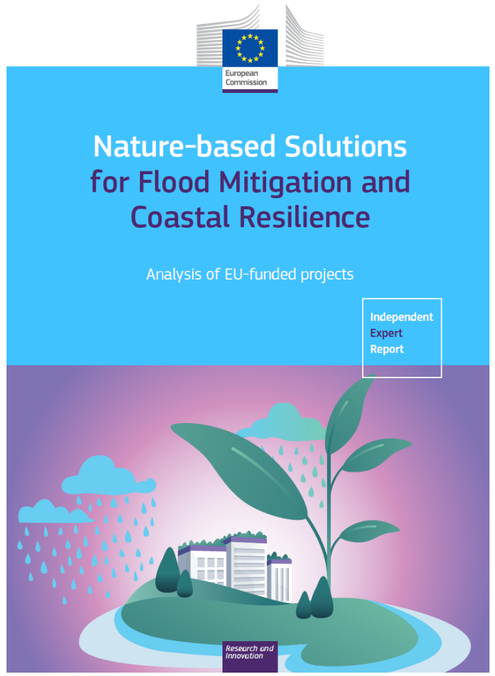

Report | 16 February 2024 | Directorate-General for Research and Innovation

The next frontier for climate change science

Insights from the authors of the IPCC 6th assessment report on knowledge gaps and priorities for research.

Report | 11 December 2023 | Directorate-General for Research and Innovation

Guidelines for co-creation and co-governance of nature-based solutions

This report analyses co-creation and co-governance approaches for Nature Based Solutions (NBS). Each project represents different ways in co-designing, co-developing, co-implementing and co-monitoring NBS that are being deployed in diverse European contexts.

Report | 10 July 2023 | Directorate-General for Research and Innovation

Harnessing the power of collaboration for nature-based solutions

This briefing paper presents practical examples and inspiration for local decision-makers on utilizing co-governance approaches to promote participatory processes and collaborative creation of nature-based solutions.

Report | 8 June 2023 | European Investment Bank

Investing in nature-based solutions

State-of-play and way forward for public and private financial measures in Europe.

Report | 27 January 2023 | Directorate-General for Research and Innovation

Nature-based solutions and the challenges of water: Accelerating the transition to more sustainable cities

Nature-based solutions are innovative approaches that regenerate areas affected by human activities, restoring key ecological functions that improve people's quality of life.

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The EU–Brazil sector dialogue on nature-based solutions

Contribution to a Brazilian roadmap on nature-based solutions for resilient cities

The European Commission and the Brazilian Ministry of Science, Technology, Innovation and Communication started a dialogue on nature-based solutions (NBS) in 2015. In this report, European and Brazilian experts analyse the occurrence and potential of NBS in Brazil, highlight good practices in the EU for

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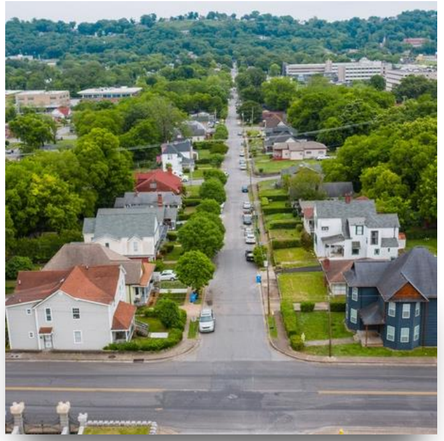
Escalas e Contextos

Escalas e Contextos

Intervenção em pequena escala: habitação, edificações e etc



Intervenção em média escala: bairros e vizinhança.

Intervenção em grande escala: cidades e entorno, área rural, bacia hidrográfica.

MUDANÇAS CLIMÁTICAS E SbN

Journal of Hydrology 619 (2023) 129284

Contents lists available at ScienceDirect

Journal of Hydrology

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Research papers

Assessing climate change impact on flood discharge in South America and the influence of its main drivers

João Paulo L.F. Brêda *, Rodrigo Cauduro Dias de Paiva, Vinicius Alencar Siqueira, Walter Collischonn

Instituto de Pesquisas Hidráulicas (IPH) at the Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, Brazil

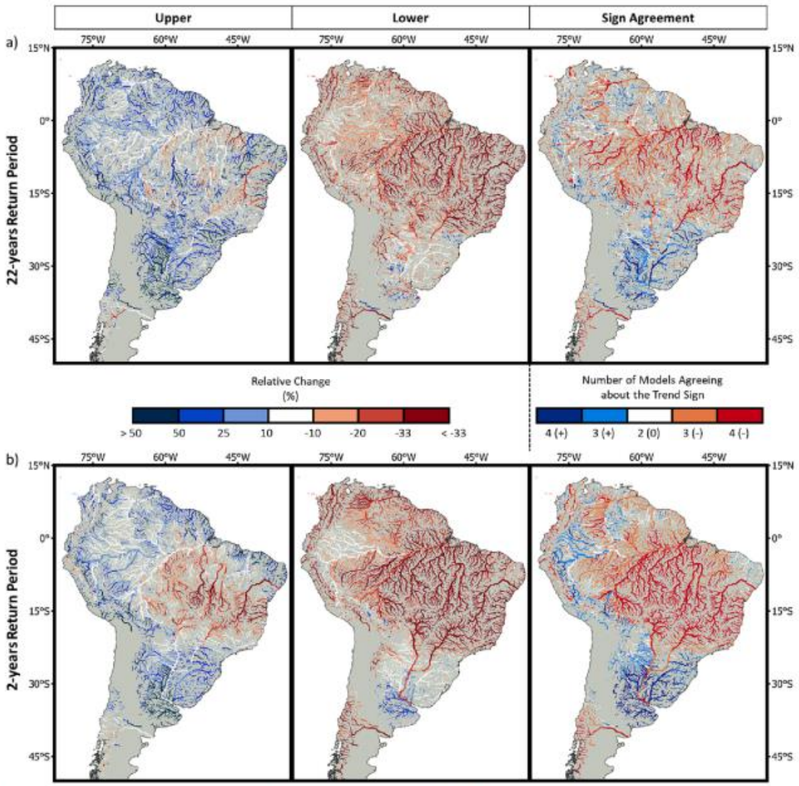

Fig. 7. Relative change of flood discharge projections for the RCP4.5 scenario compared to the historical period. The left and center panels show the upper and lower limits related to the ensemble of 4 downscaled climate models, respectively, while the right panel indicates the agreement between these models regarding the change sign. Relative differences are shown for the second-highest (a) and median (b) annual maximum discharges from the future and historical periods.

nature communications

Article

https://doi.org/10.1038/s41467-022-32580-x

Climate and land management accelerate the Brazilian water cycle

Received: 2 August 2021

Accepted: 4 August 2022

Published online: 01 September 2022

Check for updates

Vinícius B. P. Chagas[1], Pedro L. B. Chaffe[2] & Günter Blöschl[3]

Increasing floods and droughts are raising concerns of an accelerating water cycle, however, the relative contributions to streamflow changes from climate and land management have not been assessed at the continental scale. We analyze streamflow data in major South American tropical river basins and show that water use and deforestation have amplified climate change effects

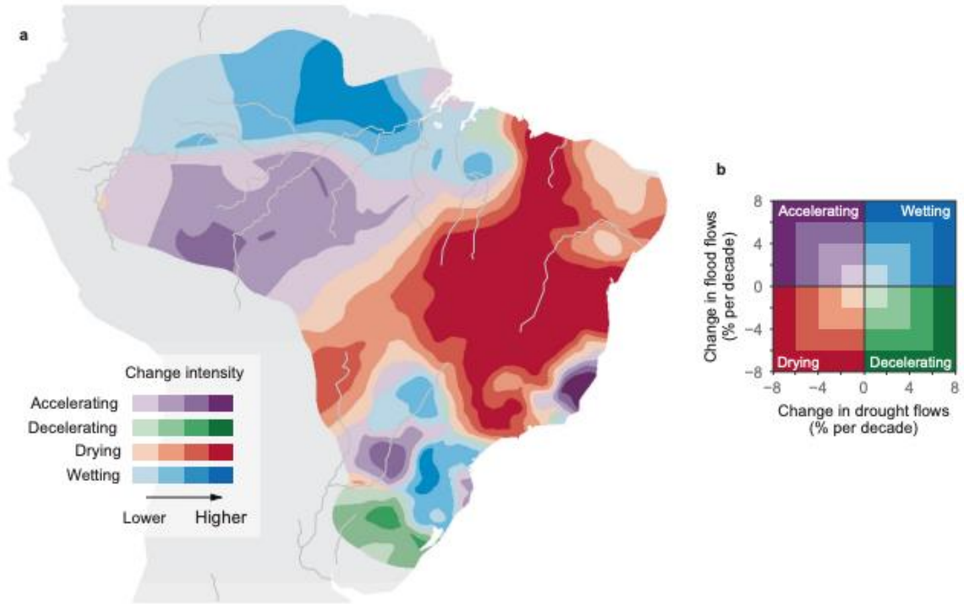

Fig. 5 | Spatial distribution of the accelerating, decelerating, wetting, and drying streamflow trends in Brazil. a The location of the four quadrants of regional streamflow trends, with darker colors indicating larger change intensities. **b** Explanation of the color code of **a**. Accelerating water cycle has occurred in 29% of the region (2.7 million km^2); deceleration in 4% (0.4 million km^2); drying in 42% (3.9 million km^2); and wetting in 25% (2.4 million km^2).

CLIMATE MITIGATION VS CLIMATE ADAPTATION

HUMAN INTERVENTION THAT REDUCES THE EMISSION OF GREENHOUSE GAS	THE PROCESS OF ADJUSTING TO THE CURRENT AND FUTURE EFFECTS OF CLIMATE CHANGE
Protect and restore forests	Flood protection
Improve energy efficiency	Biodiversity conservation
Adapt agricultural practices	Climate resilient buildings
Sustainable waste management	Disaster risk management

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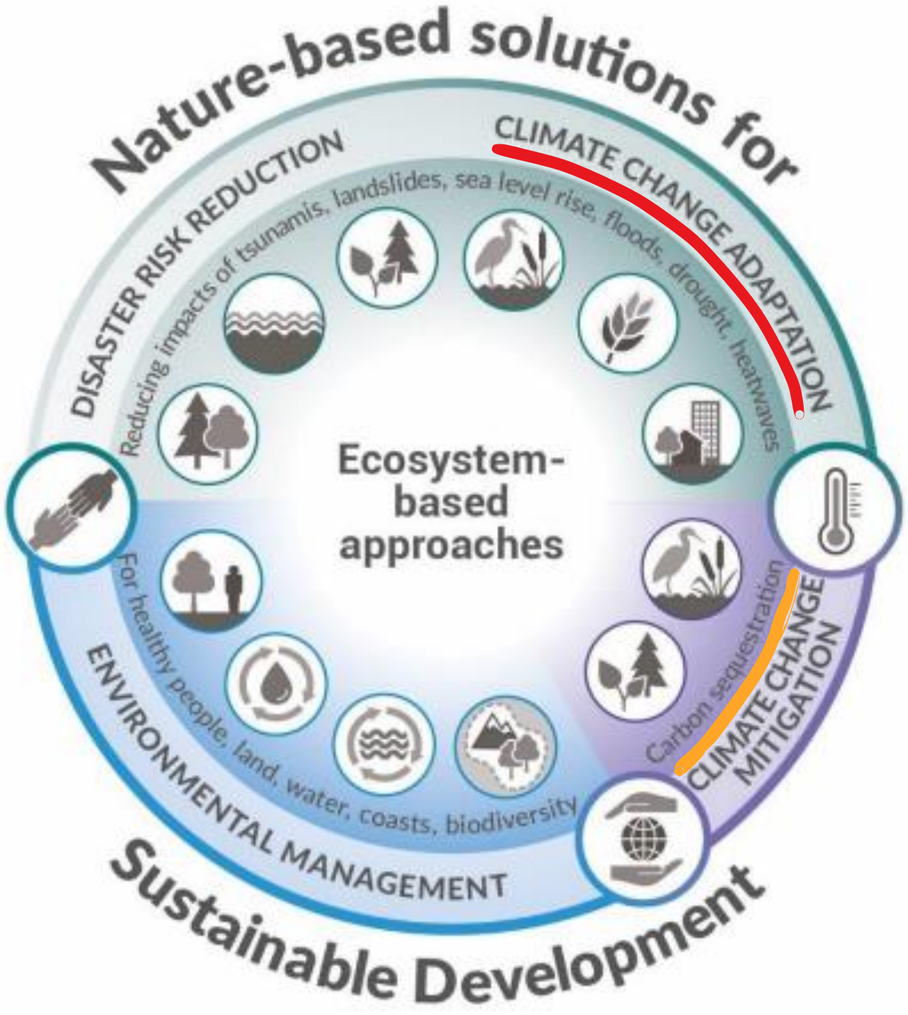
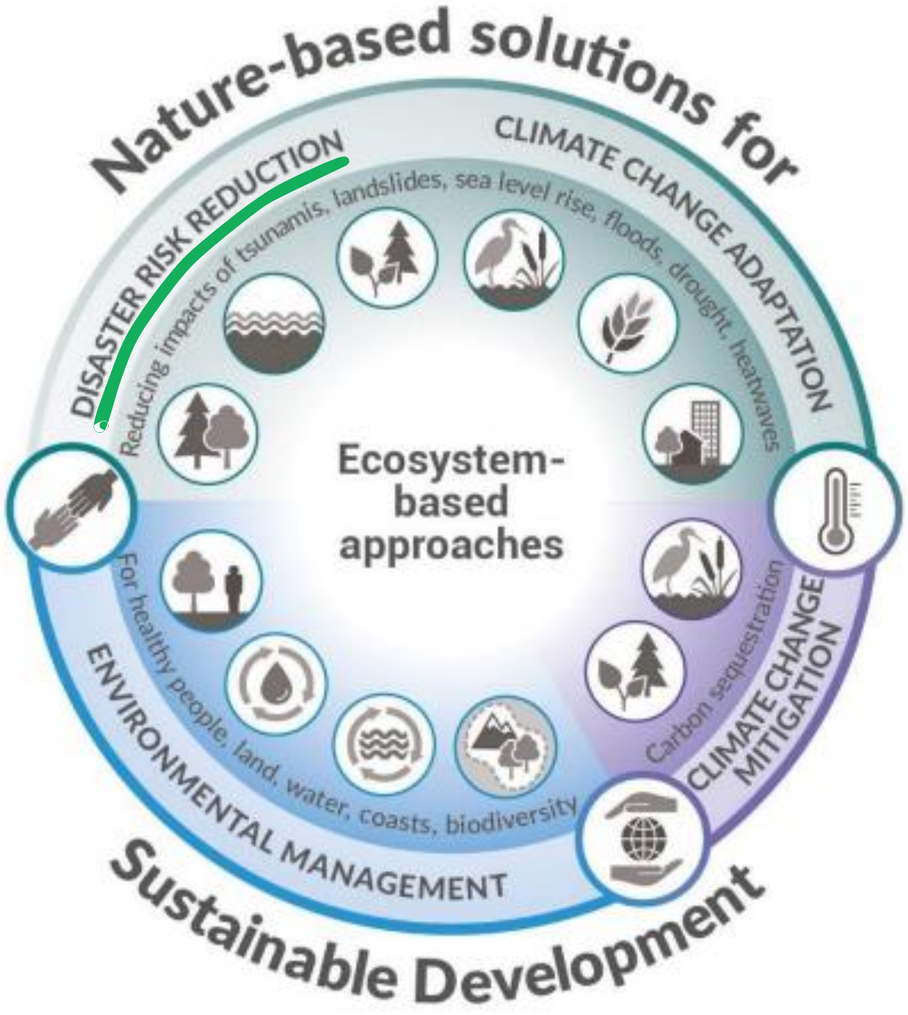


Source: UNEP/PEDRR 2020

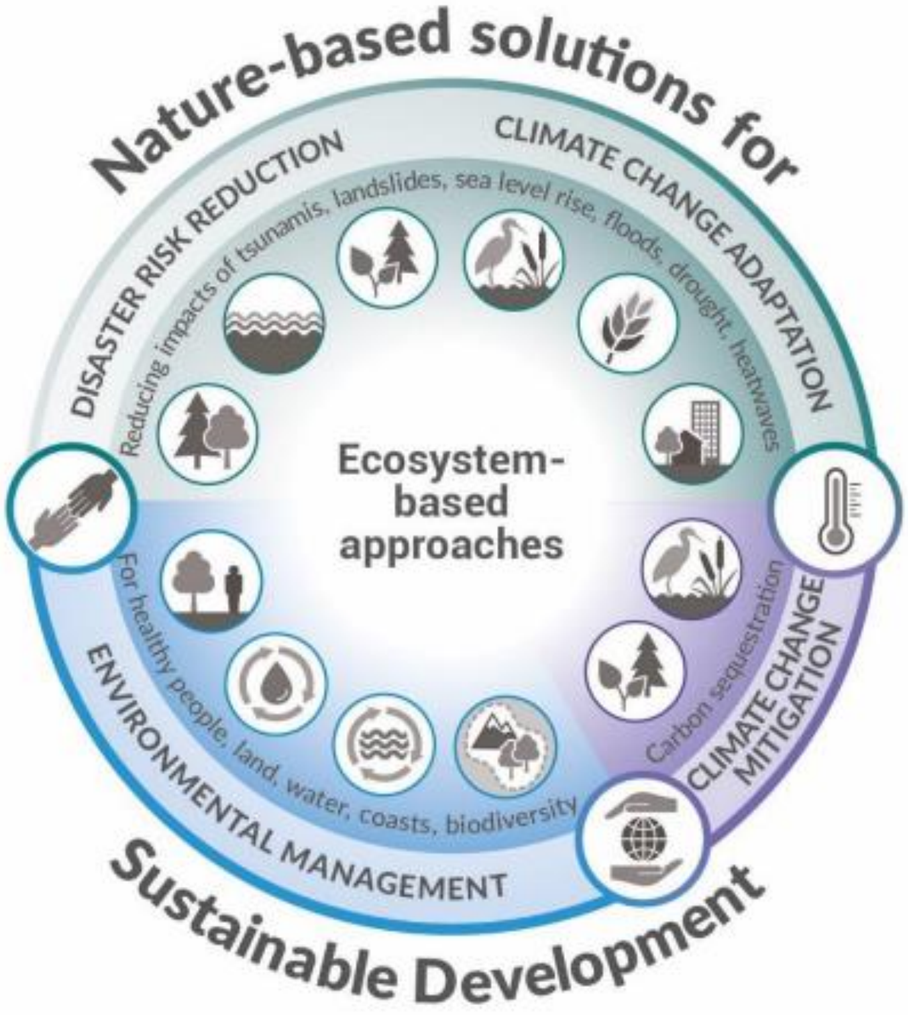
https://doi.org/10.1016/j.landurbplan.2018.10.003



Source: UNEP/PEDRR 2020

- Meeting the needs of people
- Green infrastructure
- Blue infrastructure
- Landscape restoration
- Taking care of our planet for the long-term
- Wetland restoration
- Climate smart agriculture/agroforestry
- Urban greening
- Sustainable land & integrated fire management
- Dealing with climate change
- Integrated water resource management
- Integrated coastal zone management
- Protected areas

https://doi.org/10.1016/j.landurbplan.2018.10.003



Source: UNEP/PEDRR 2020

https://doi.org/10.1016/j.landurbplan.2018.10.003

- Disaster Risk = Hazard x Vulnerability x Exposure

HAZARD	VULNERABILITY	EXPOSURE
Ecosystem degradation can lead to hazards like landslides Climate change impacts on certain hazards and regions	Poverty, environmental degradation and hazardous living conditions Poor governance and lack of preparedness to hazard events Social inequalities, marginalization and low coping capacities	Lack of urban planning processes Inappropriate settlement locations, e.g. on steep slopes, on floodplains, etc. Lack of evacuation plans and/or early warning systems

Soluções baseadas na Natureza: Multiplas funções e co-benefícios

NATURE-BASED SOLUTIONS

NBS

NBS are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. (IUCN)

BENEFITS

NBS provide benefits not only solving the initial problem but also useful for environment and society. Such as climate regulation, recreation, health, tourism, food and drinking water.

INITIAL PROBLEM → CLIMATE REGULATION

→ HEALTH

→ RECREATION, TOURISM, FOOD AND DRINKING WATER

Multifuncionalidades e co-benefícios

Produção de Alimentos

SbN ajudam na produção de alimentos por meio de plantas e animais silvestres. Parte da biomassa pode ser usada como matéria-prima para a alimentação.

Fonte: Haines-Young e Potschin (2018)

Uso de biossólidos

Os biossólidos provenientes do tratamento de águas residuais podem ser aplicados como fertilizantes, promovendo solos produtivos e crescimento vegetal.

Fonte: US Environmental Protection Agency (2021)

Recreação e Valor estético

SbN valorizam paisagens naturais e restauradas, criando espaços agradáveis para moradia, lazer e bem-estar comunitário.

Fonte: Millennium Ecosystem Assessment (2005)

Regulação do clima

SbN ajudam a regular a temperatura e a umidade, aliviando condições climáticas extremas por meio da ventilação e transpiração.

Fonte: Haines-Young e Potschin (2018)

Reuso da água

Águas residuais tratadas podem ser reutilizadas para irrigação, abastecimento de água potável e restauração ambiental, promovendo sustentabilidade.

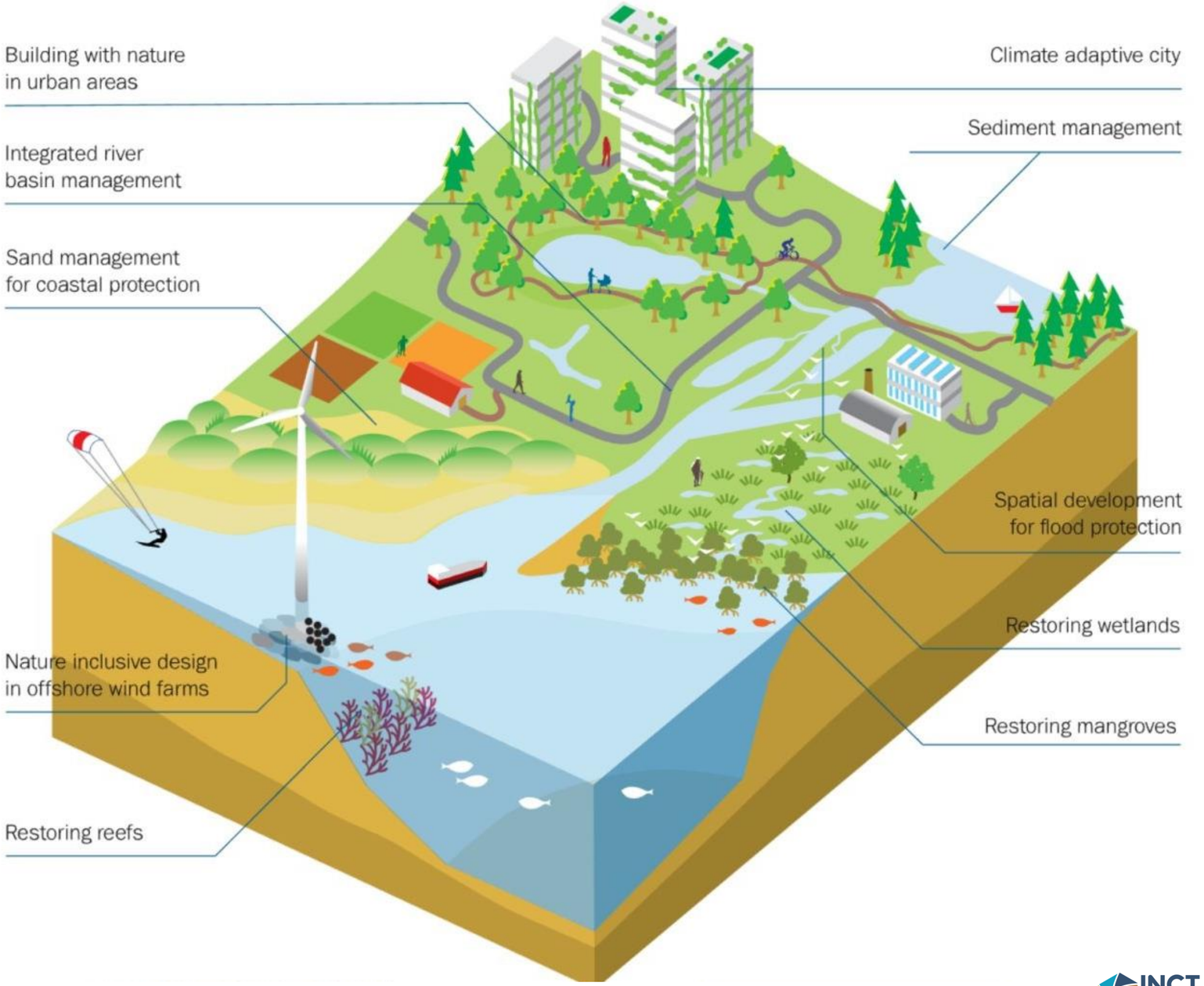
Fonte: ISO (2018); US EPA (2021)

Biodiversidade

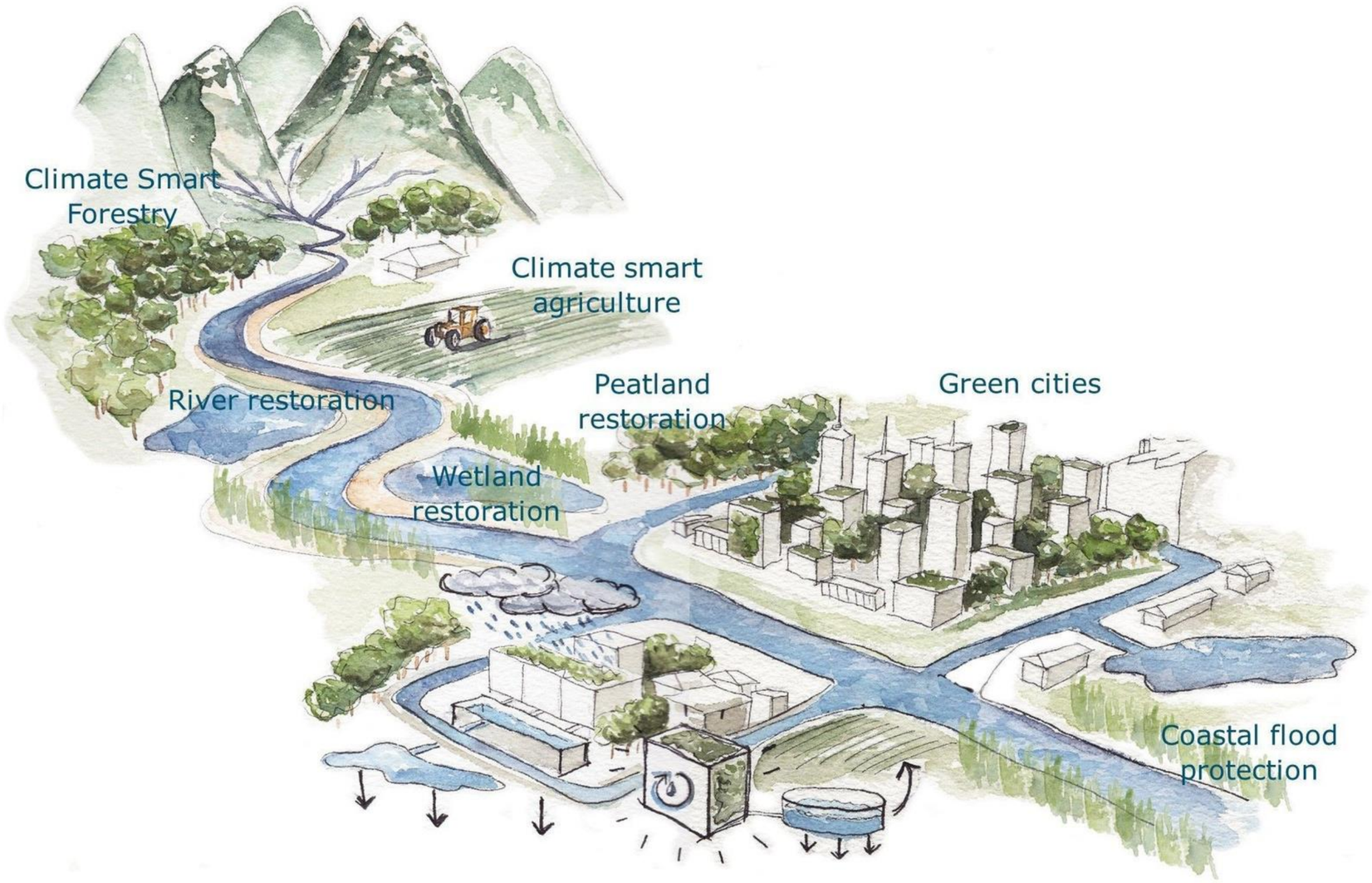
SbN aumentam a diversidade de fauna e flora, promovendo equilíbrio ecológico em ambientes terrestres e aquáticos.

Fonte: Adaptado da Convenção sobre Diversidade Biológica (1992)

Nature Based Solutions



Nature Based Climate Solutions



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Uso de Soluções baseadas na Natureza (SbN) pela Gestão Pública Brasileira no Manejo de Águas Pluviais Urbanas

Use of Nature-based Solutions (NbS) by Brazilian Public Administration on Urban Stormwater Management

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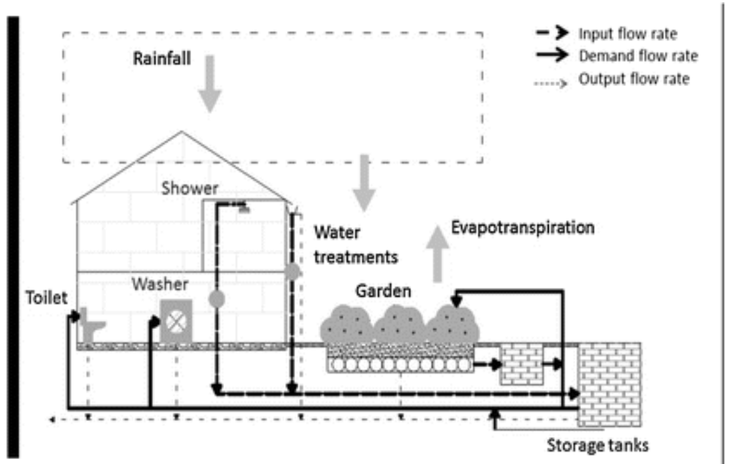
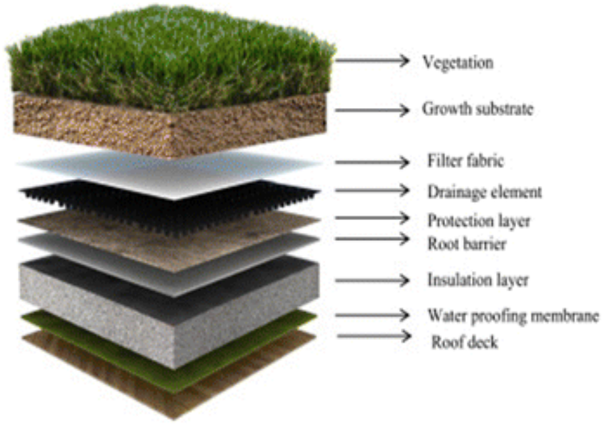
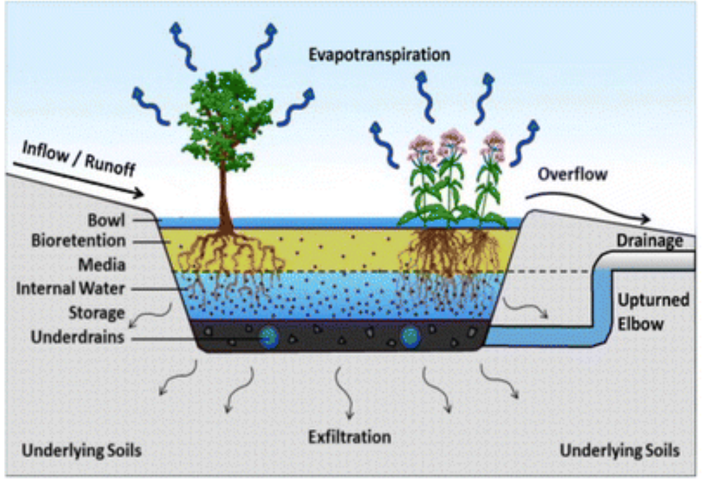


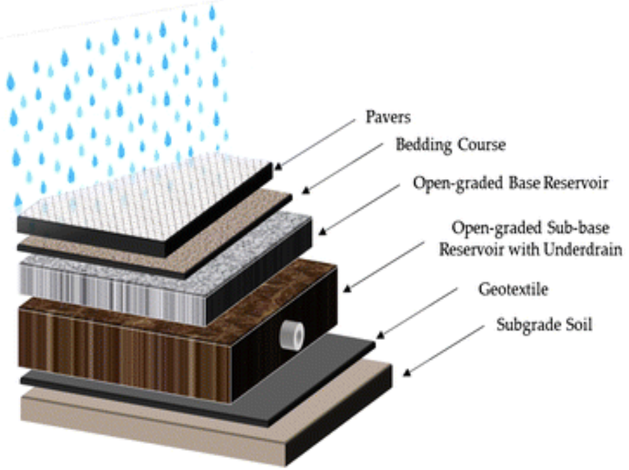
Rainwater Harvesting



Greenroof



Urban Green Space



Pervious Pavements

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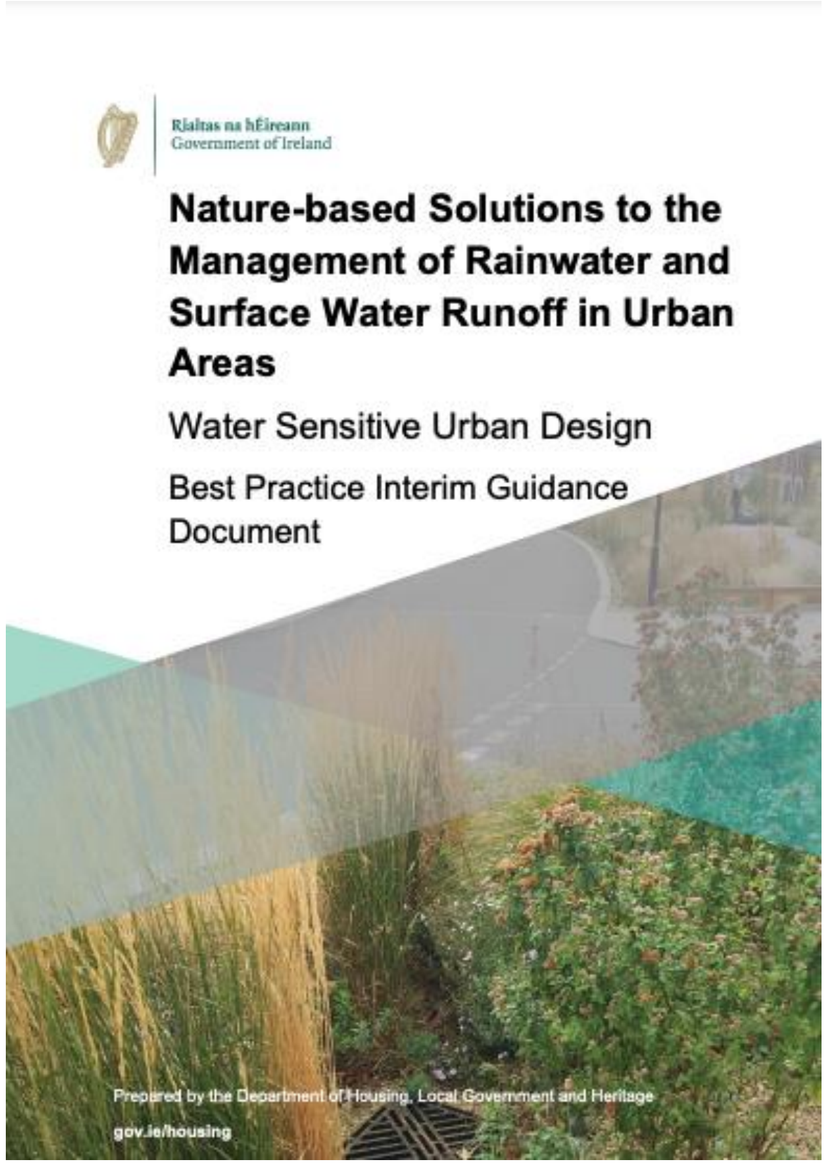
Tabela 3 – Menções às diferentes SbN estudadas e respectivas abordagens

SbN	Abordagem	Sul			Sudeste				Brasil
		Curitiba PR	Florianópolis SC	Porto Alegre RS	Belo Horizonte MG	Rio de Janeiro RJ	São Paulo SP	Vitória ES	Brasília DF
Pavimentos permeáveis	Gerenc./Planej.[1]	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
	Imp./Exec.[2]	Sim	Não	Não	Não	Não	Sim	Não	Sim
	Norm./Dim.[3]	Sim	Não	Sim	Sim	Não	Sim	Não	Sim
Poços de infiltração	Gerenc./Planej.	Sim	-[4]	Não	Sim	-	Sim	-	Sim
	Imp./Exec.	Não	-	Não	Sim	-	Não	-	Não
	Norm./Dim.	Sim	-	Sim	Sim	-	Sim	-	Sim
Trincheira de infiltração	Gerenc./Planej.	Sim	-	Não	Sim	Sim	Sim	-	Sim
	Imp./Exec.	Não	-	Não	Sim	Não	Não	-	Não
	Norm./Dim.	Sim	-	Sim	Sim	Não	Sim	-	Sim
Valas de infiltração	Gerenc./Planej.	Sim	Sim	Não	Sim	Sim	Sim	-	Sim
	Imp./Exec.	Não	Não	Não	Não	Não	Não	-	Sim
	Norm./Dim.	Sim	Não	Sim	Sim	Não	Sim	-	Sim
Parques lineares	Gerenc./Planej.	Sim	Sim	-	Sim	Sim	Sim	-	Sim
	Imp./Exec.	Sim	Não	-	Sim	Não	Não	-	Não
	Norm./Dim.	Sim	Não	-	Não	Não	Não	-	Sim
Jardins de chuva	Gerenc./Planej.	Sim	-	-	Sim	Sim	Não	-	Não
	Imp./Exec.	Não	-	-	Sim	Não	Não	-	Não
	Norm./Dim.	Sim	-	-	Sim	Não	Sim	-	Sim
Cobertura/ telhado verde	Gerenc./Planej.	Sim	-	-	Sim	Sim	Sim	-	Não
	Imp./Exec.	Não	-	-	Sim	Não	Não	-	Não
	Norm./Dim.	Não	-	-	Sim	Não	Sim	-	Sim
Banhados construídos (*wetlands* construídos)	Gerenc./Planej.	Sim	-	-	Não	Sim	Sim	-	-
	Imp./Exec.	Não	-	-	Sim	Não	Não	-	-
	Norm./Dim.	Sim	-	-	Não	Não	Sim	-	-



Swale Source: C Galvin, South Dublin CoCo

Grasscrete Source: D Joyce, Cork City CoCo

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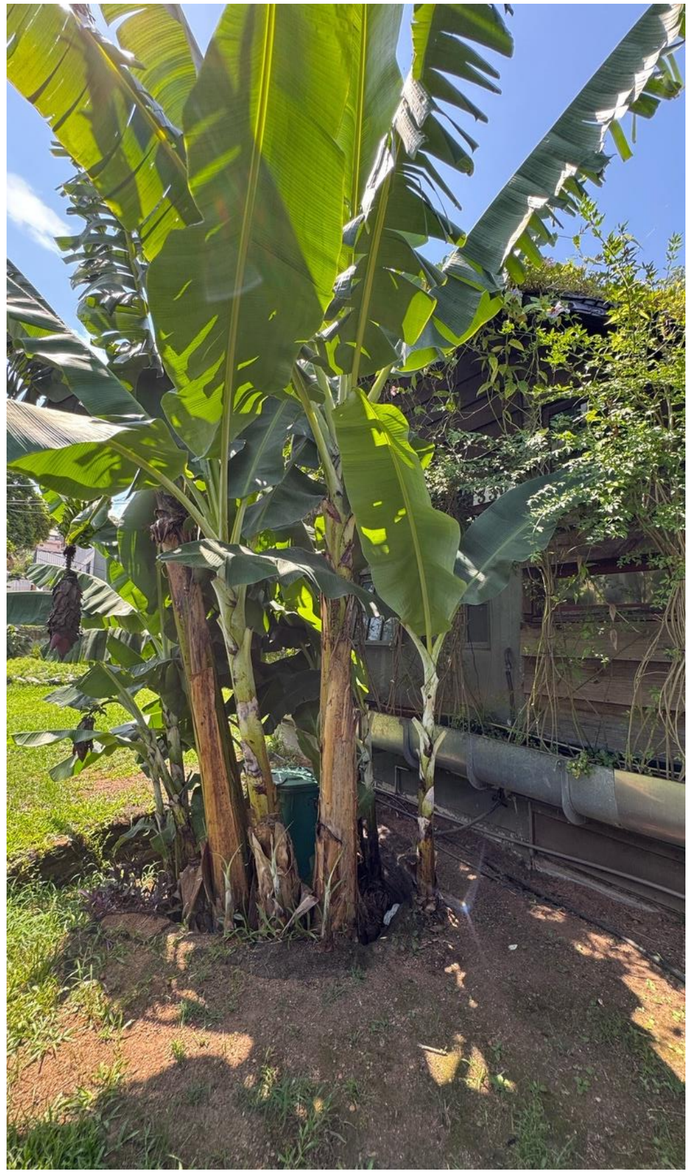

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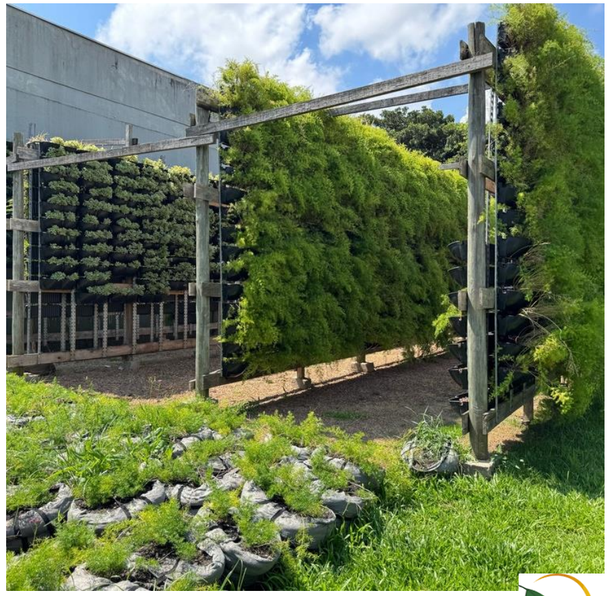

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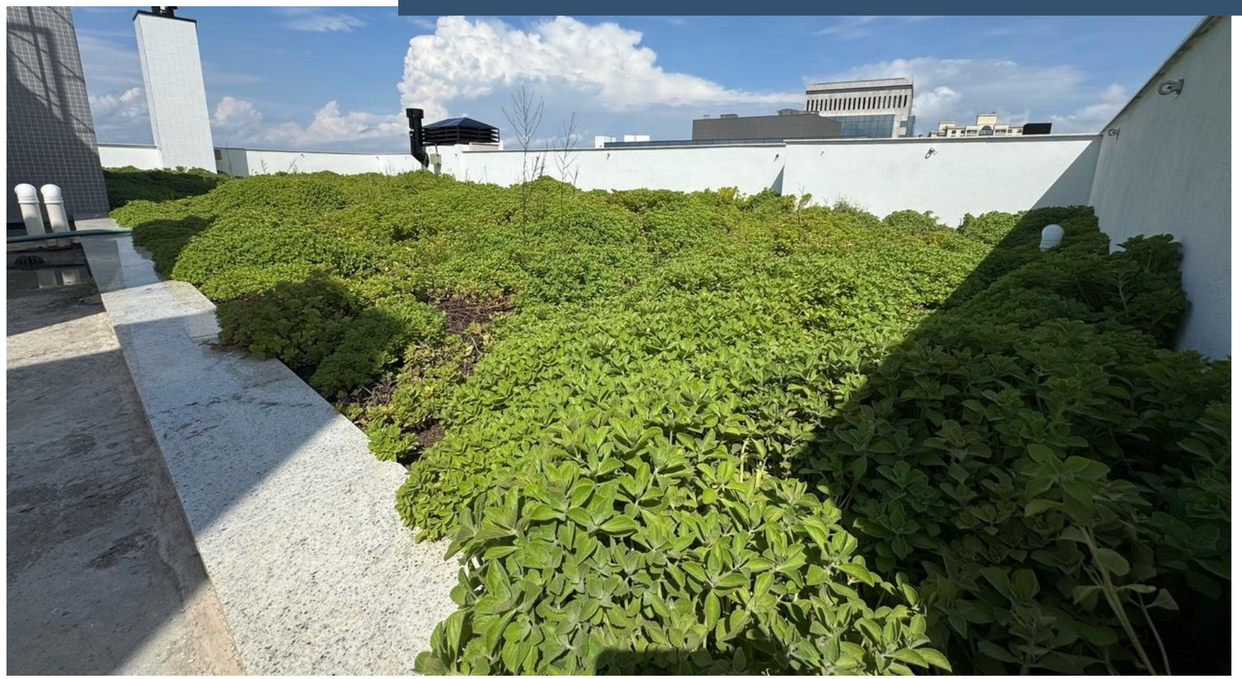

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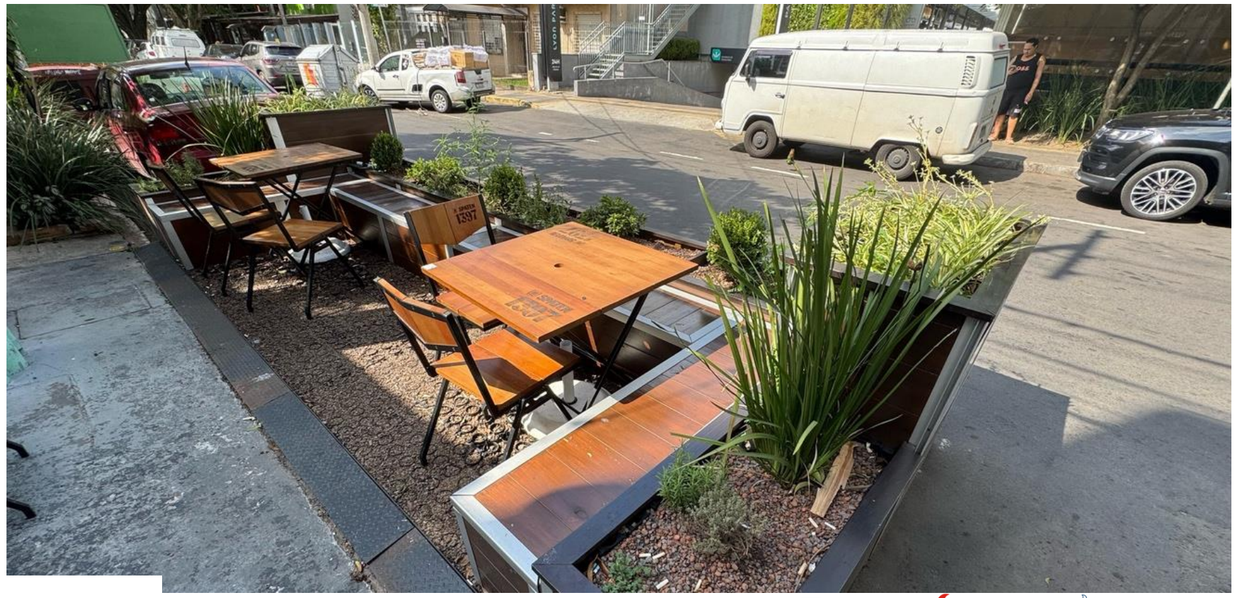

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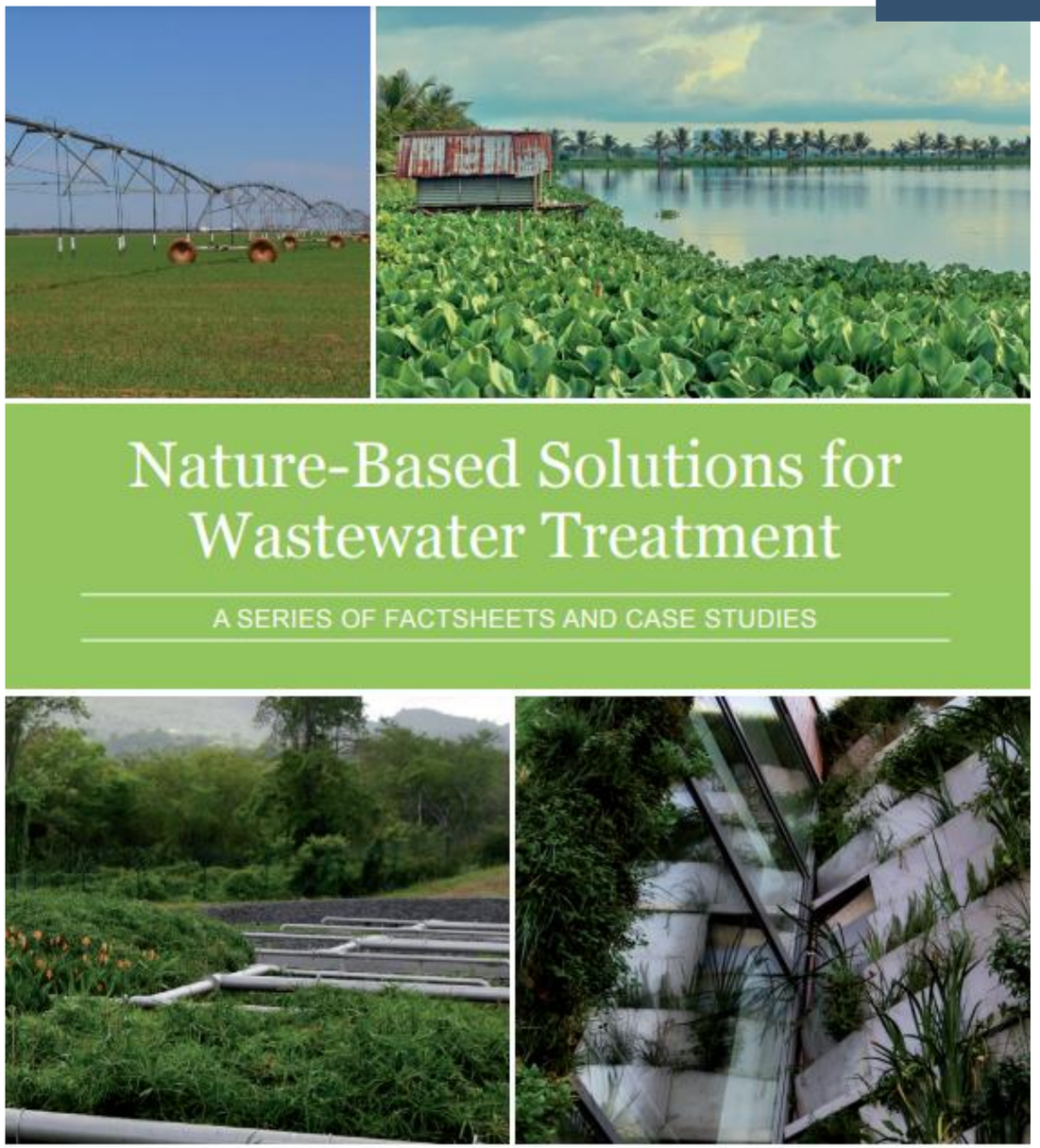

IWA PUBLISHING

The Nature Conservancy | IWA the international water association | SNAPP Science for Nature and People PARTNERSHIP

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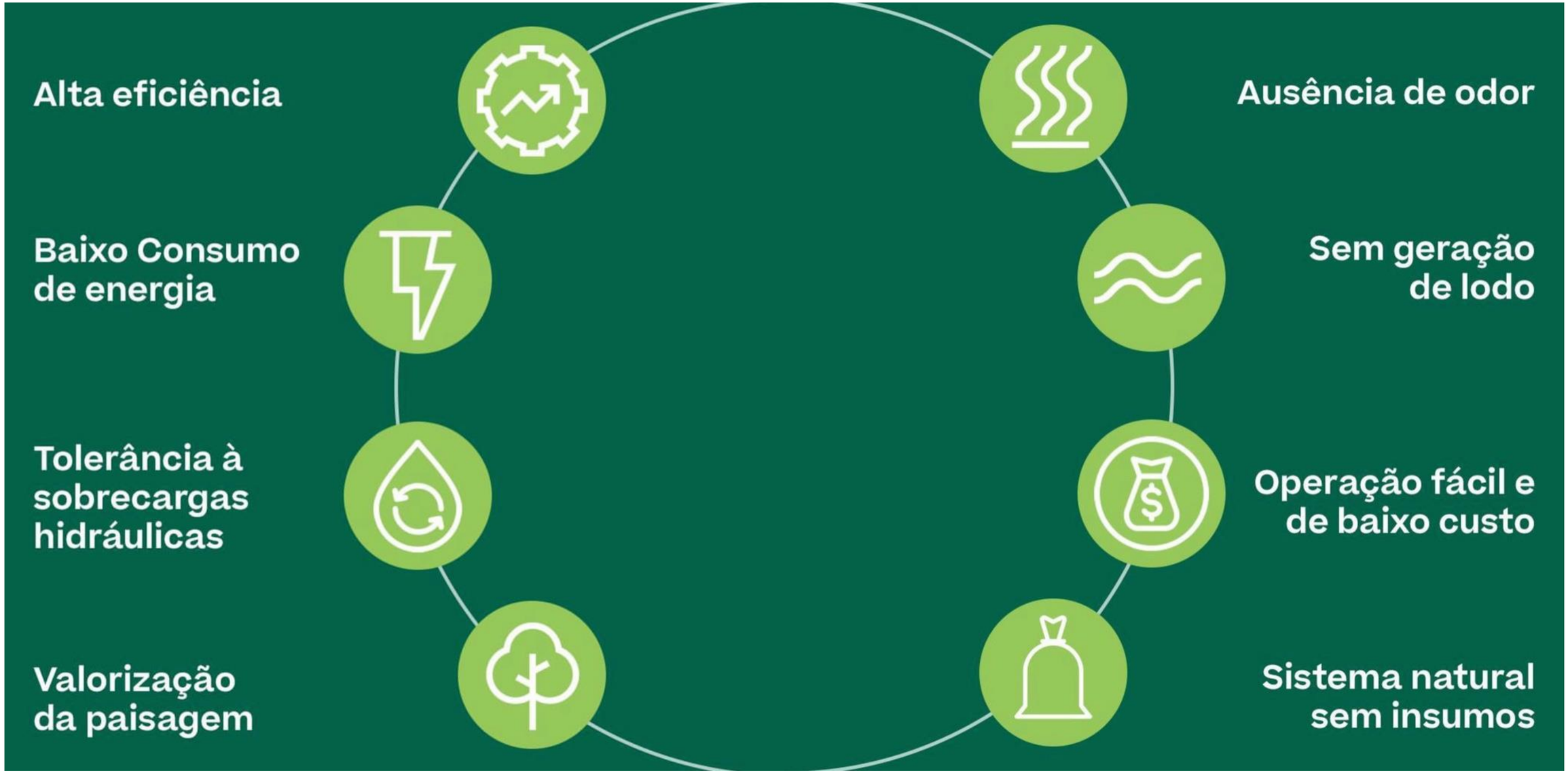
#NATUREBASEDSOLUTIONS
Wastewater treatment...which would you choose?
A
B
Conventional Infrastructure
Nature-Based Solutions (NBS)
CREW
Center for Restoration of Ecosystems and Watersheds
The University of Oklahoma

ESGOTO
ETE
BIOGÁS
EFLUENTE TRATADO
LODO
ETE CONVENCIONAL
QUEIMADORES
CORPO RECEPTOR
ATERRO SANITÁRIO
ETE SUSTENTÁVEL
ENERGIA
ÁGUA PARA REÚSO
BIOSSÓLIDO



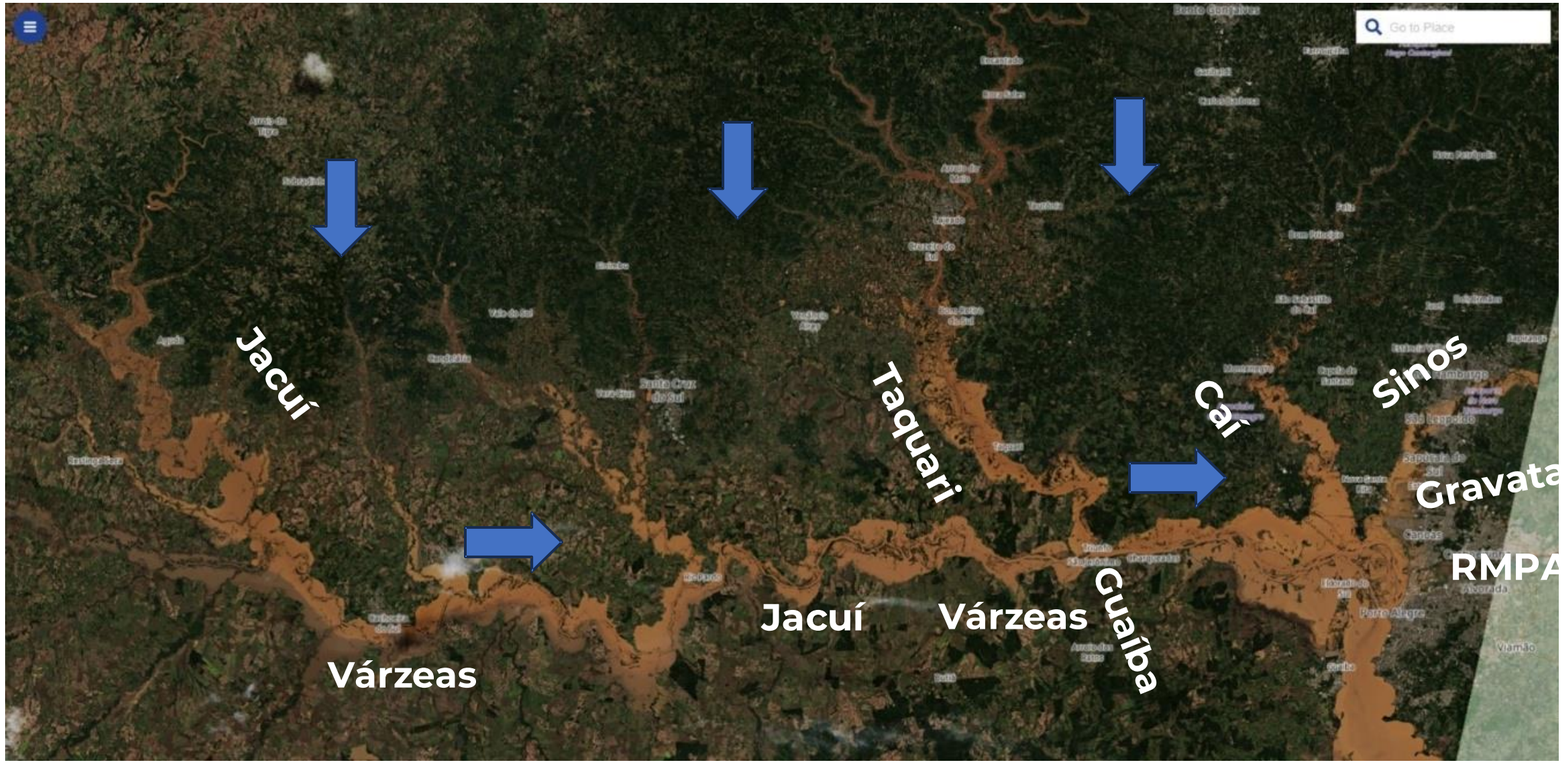
Fonte: Phytorestore.

Desastres

Extreme Event

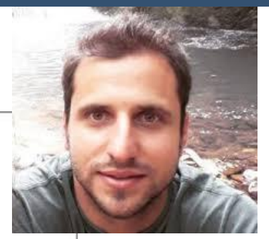
Extreme and rapid floods in the various rivers of the mountain. (>20 m in a few hours. High flow speed)

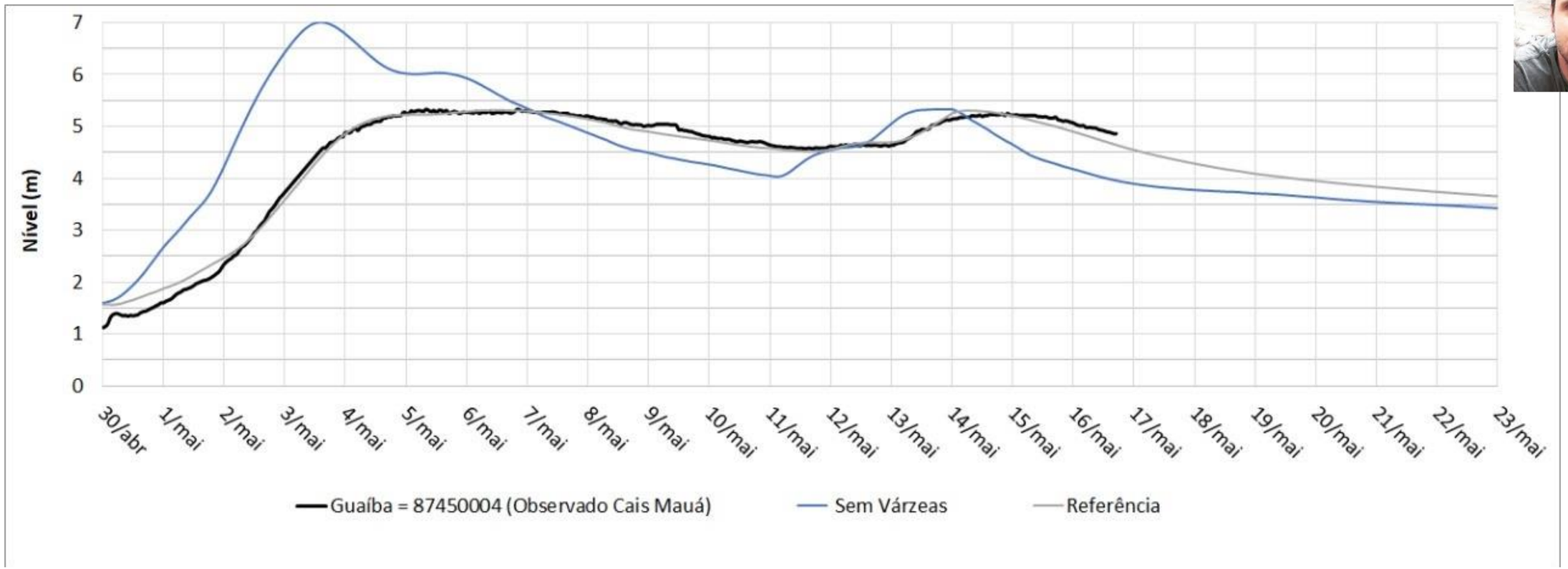
Landslides >15.000



30 days of inundation

10 km
Credit: European Union, contains modified Copernicus Sentinel data 2024





The important role of floodplains. In the **hypothetical scenario** - in which **there are no floodplains**, the **flood wave would arrive much faster**. Levels would rise **2 days earlier**, reaching **more than 7 m**, **exceeding the maximum reached by around 2 m**. The floodplains act by dampening and delaying the flood wave, reducing its magnitude, *but on the other hand increasing its duration*.

Aplicações, estudos e projetos

Nimr Water Treatment Project, Oman – 175.000 m^3/d

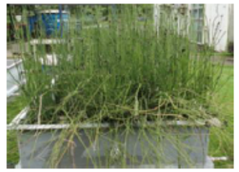
https://www.bauer.de/export/shared/documents/pdf/bre/brochures/Constructed_Wetlands.pdf

BAUER
ReedBox

BRK
Rotária
do Brasil

240 Lps, 7,5 ha

Wetland Construído – HF, Multiestágio
UASB + FB
95%
91%
92%
88%
99,98%
89%
100%
80%
60%
40%
20%
0%
DBO
DQO
PT
Nam
CT
SST

Author, Country and Configuration	Informations Main aspects	Image
Paulo et al., (2013) Brazil Multi-stage system Subsuperficial Horizontal Flow + Vertical Flow	Residence of a social project, horizontal flow with 4.6 m^2, grease box and sedimentation tank as pre-treatment, hydraulic loading rate (HLR): 360 $mm.d^{-1}$ (hydraulic retention time (HRT) - 3.4 days), fine gravel as a filter medium. Vertical flow as post-treatment, HLR: 150 $mm.d^{-1}$, 2 to 3 batches, coarse sand as a filter medium.	
Gonçalves et al., (2020) Brazil Vertical flow	University campus, 2.6 m^2, sand as a filter medium, HLR: 300-800 $mm.d^{-1}$, 3-9 batches.	
Platzer et al., (2016) Peru Vertical flow	School, Population Equivalent: 70 inhabitants, flow: 1.5 $m^3.d^{-1}$, 16 m^2, 1 m^3 of sedimentation tank as pre-treatment, coarse sand as a filter medium, reused for irrigation.	
Platzer et al., (2016), Peru Vertical flow	Guest building, 160 apartments, 2 modules of 50 m^2, flow 6 $m^3.d^{-1}$, grease trap and sedimentation tank as pre-treatment, organic loading rate (OLR) of 25 g $BOD.m^2.d^{-1}$, reuse after disinfection for irrigation and toilet flush.	
Platzer et al., (2016) Peru Vertical flow	Building of social project, 60 m^2, divided into 3 modules, to operate with bed rest, HLR 150 $mm.d^{-1}$.	
Magalhães Filho and Paulo (2021) Brazil Horizontal Flow	High standard residence, 9 years of operation, 2 m^2, greywater without kitchen sink, pre-treatment with planted anaerobic filter, HLR: 50-120 $mm.d^{-1}$ (peaks 500-600 $mm.d^{-1}$), OLR: 5.5-6.6 $gCOD.m^{-2}.d^{-1}$ (inlet), effluent with ~63	

CHAPTER

7

Phytoremediation as a modular approach for greywater treatment

Fernando Jorge Magalhães Filho (Correa)[1,2,3,4],
Paula Paulo (Loureiro)[5,6,7,8,9]

Horizontal Flow (HF)

Vertical Flow (VF)

Hybrid Flow (HF - VF)

Hybrid Flow (VF - HF)

Hybrid Flow (HF-VF and VF-HF)

Hybrid Flow (VF and HF)

RBRH
Revista Brasileira de Recursos Hídricos
Brazilian Journal of Water Resources
Versão On-line ISSN 2318-0331
RBRH, Porto Alegre, v. 28, e40, 2023
Scientific/Technical Article

https://doi.org/10.1590/2318-0331.282320230007

Quali-quantitative evidence on water quality by a governance process with payment for environmental services in a water supply watershed

Evidências quali-quantitativas da qualidade da água por um processo de governança com pagamento por serviços ambientais em uma bacia hidrográfica de abastecimento de água

Frederico Luiz de Freitas Júnior[1], Mariana de Souza Pereira[1], Cristovão Vicente Scapulatempo Fernandes[2], Fernando Mainardi Fan[3], Reginaldo Brito da Costa[1] & Fernando Jorge Correa Magalhães Filho[3]

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[2]Universidade Federal do Paraná, Curitiba, PR, Brasil
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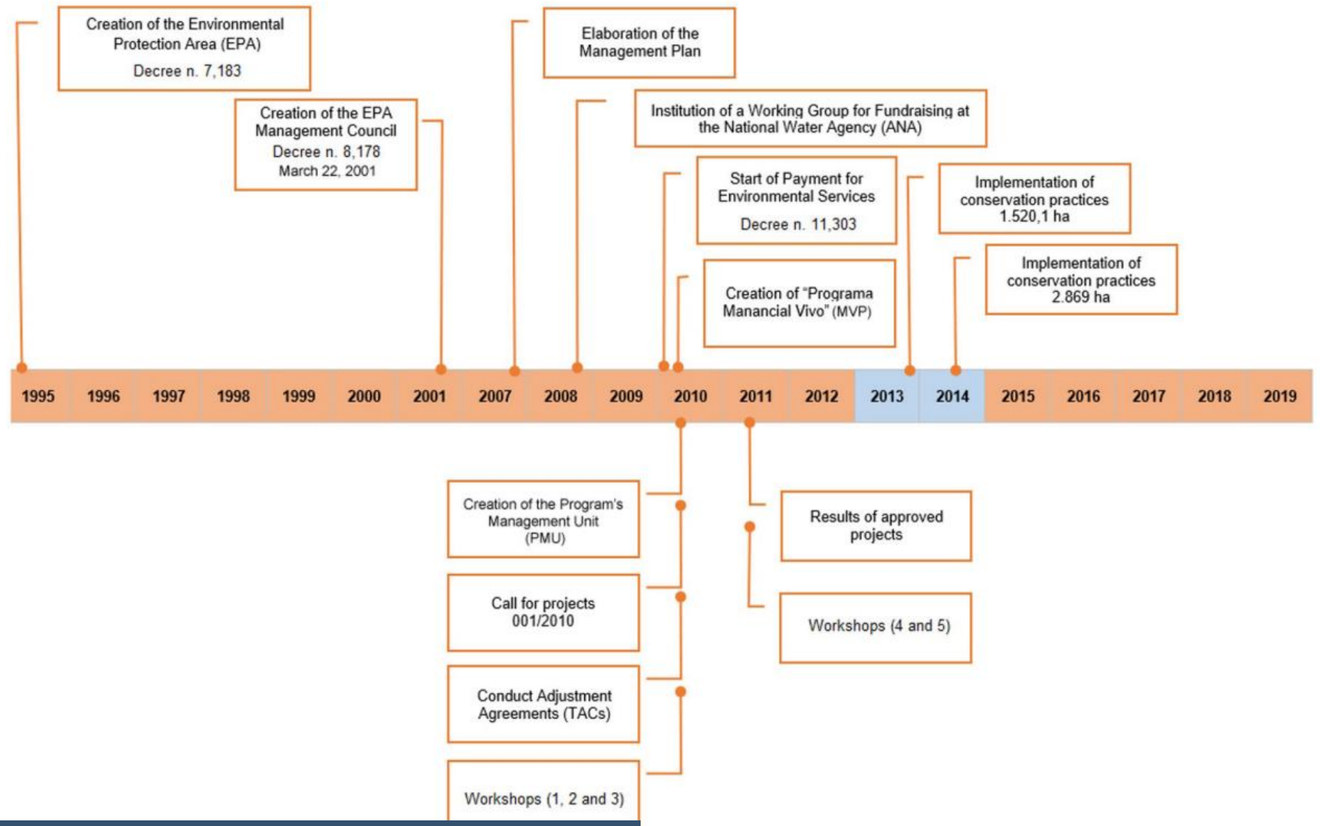


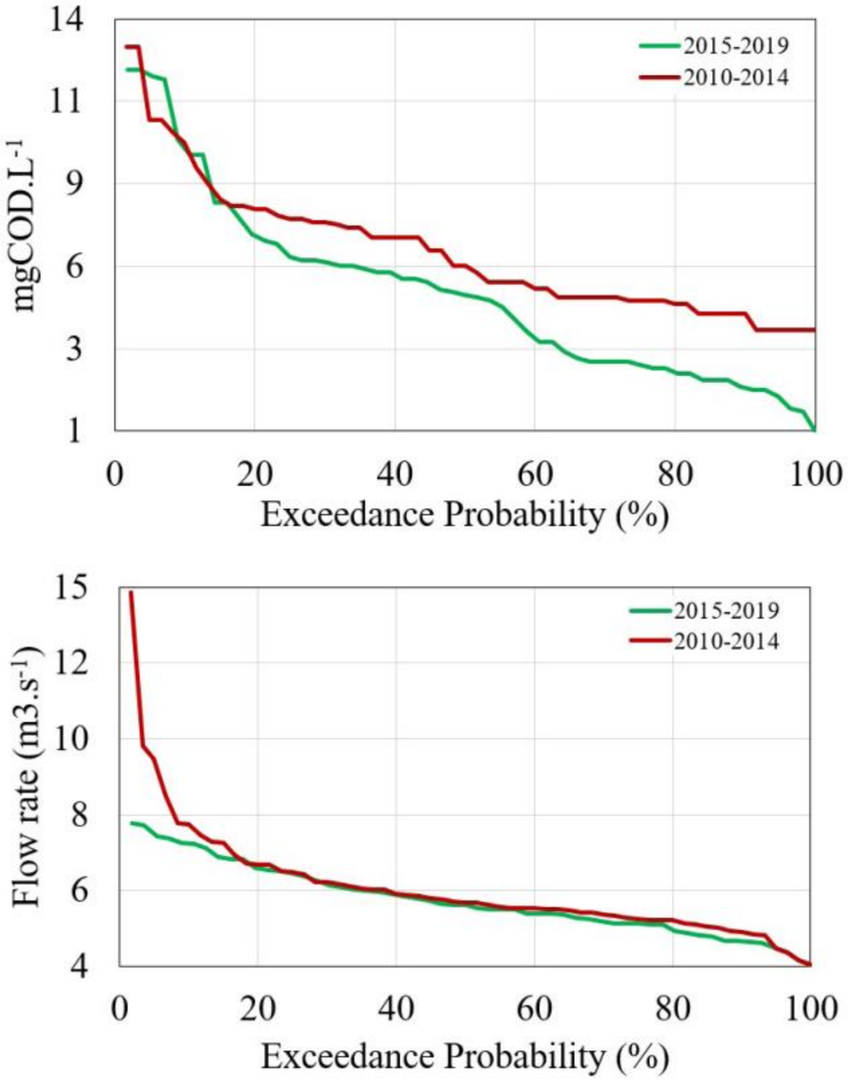


Figure 9. Flow rate and COD duration curves (2010-2014 and 2015-2019), before and after actions in the basin.

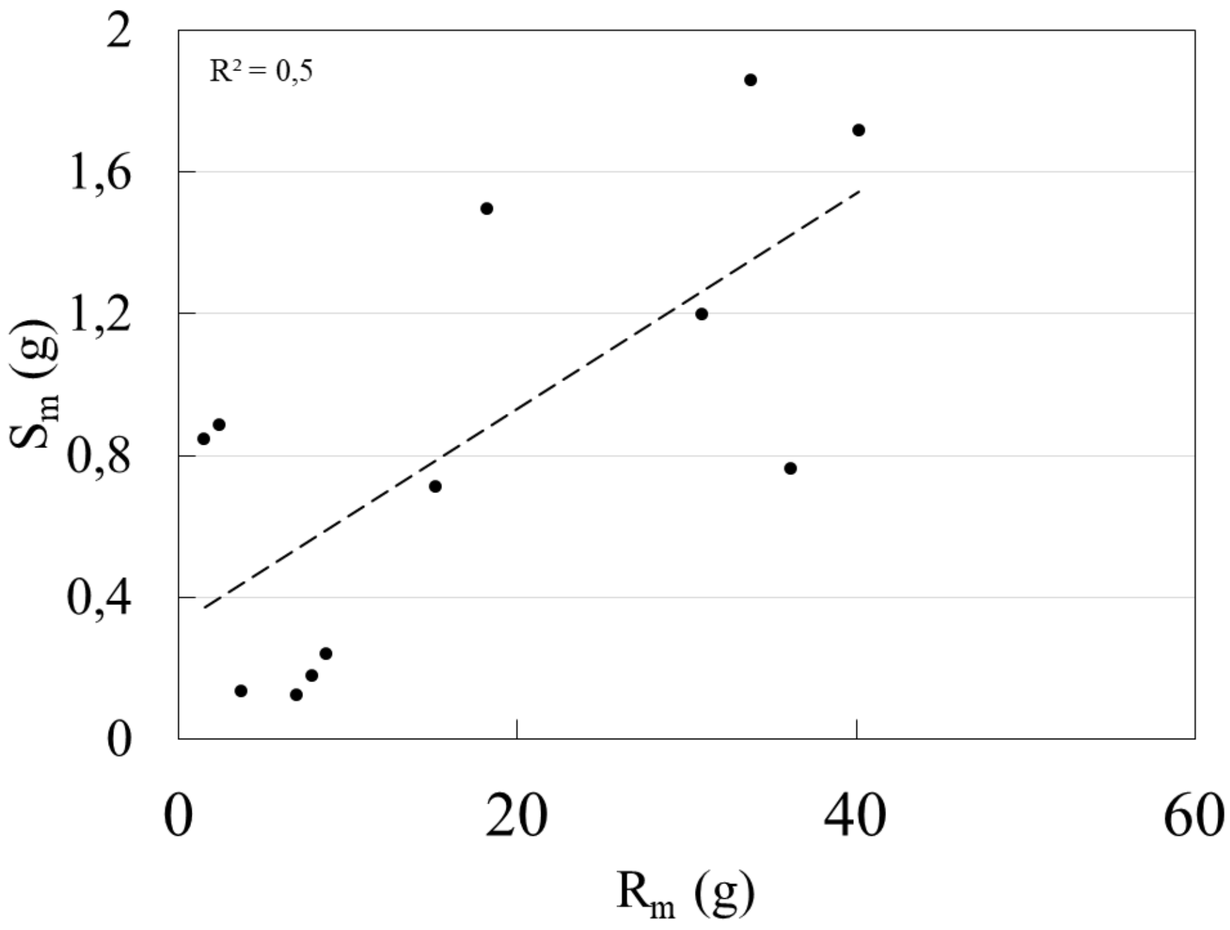


Fig. 6. Correlation between root mass and suspended solid mass entrapped by the *Pistia stratiotes* biofilm.

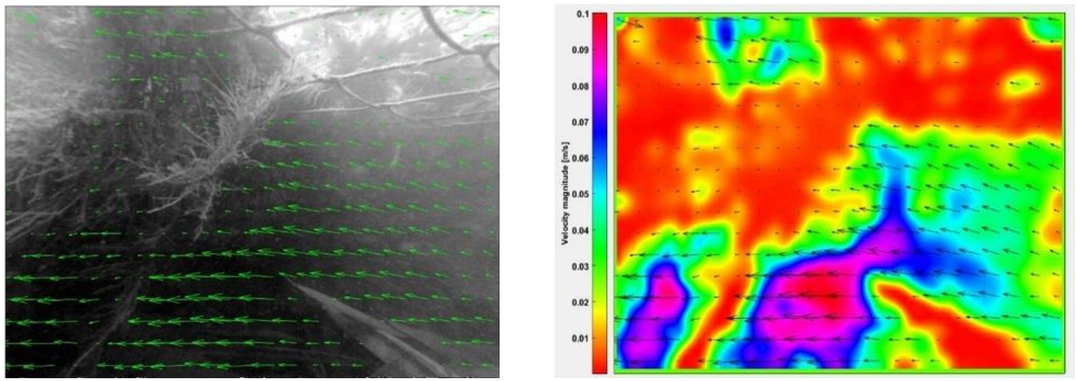
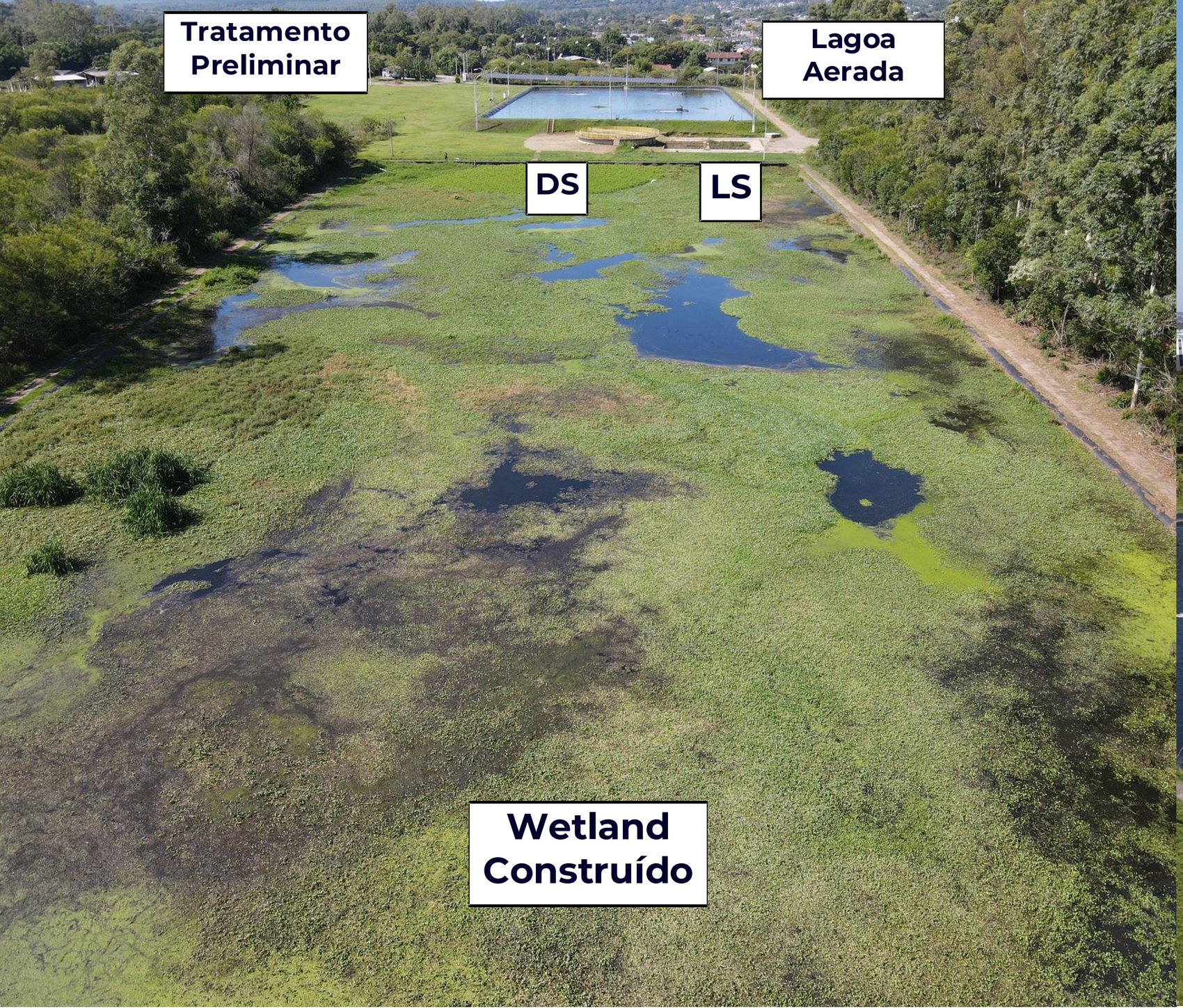


Fig. 5. Particle Image Velocimetry vertical velocity profile.


Tratamento Preliminar
Lagoa Aerada
DS
LS
Wetland Construído

28 Lps, 1,5 ha
Lagoa Aerada

Large-scale

Large-scale

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/watres

ELSEVIER

WATER RESEARCH

Review

Clogging in subsurface-flow treatment wetlands: Measurement, modeling and management

Jaime Nivala [a,b], *Paul Knowles* [c,d], *Gabriela Dotro* [e,f,*], *Joan García* [g], *Scott Wallace* [h]

Sustentare
SOLUÇÕES AMBIENTAIS

Gustavo Bartelli

4

Hotel, turismo

Farroupilha, Serra Gaúcha - RS

Sustentare
SOLUÇÕES AMBIENTAIS

4 hab

Laboratório agroindústria

Farroupilha, Serra Gaúcha - RS

Resources, Conservation & Recycling 147 (2019) 61–66

Contents lists available at ScienceDirect

Resources, Conservation & Recycling

journal homepage: www.elsevier.com/locate/resconrec

Full length article

Evapotranspiration tank for the treatment, disposal and resource recovery of blackwater

Paula Loureiro Paulo*, Adriana Farina Galbiati, Fernando Jorge Correa Magalhães Filho[1], Fernando Silva Bernardes, Glauber Altrão Carvalho, Marc Árpád Boncz

Faculty of Engineering, Architecture and Urbanism and Geography, Federal University of Mato Grosso do Sul, Av. Costa e Silva, S/N, Cidade Universitária, CEP:79.070-900, Campo Grande, MS, Brazil

ARTICLE INFO

Keywords:
Design criteria
Ecotechnology
Natural system
Reuse
Sewage
Zero liquid discharge

$$A = (n \cdot Q_d)/(ET_0 \cdot K_{TEvap} - P \cdot K_i) \quad (1)$$

where:

A = *superficial area of the TEvap, in* m^2;

n = *average number of users of the system;*

Q_d = *average flushing volume per person, in* $L \cdot d^{-1}$, *according to the flushing device used and the average number the toilet is used per person;*

K_{TEvap} = *tank's evapotranspiration coefficient, determined as 2.71 given the conditions during the experimental period;*

ET_0 = *average baseline (reference) evapotranspiration rate, in* $mm \cdot d^{-1}$;

P = *average daily precipitation at the location of the TEvap tank, in* $mm \cdot d^{-1}$;

k_i = *coefficient of infiltration, varying between 0 and 1.*

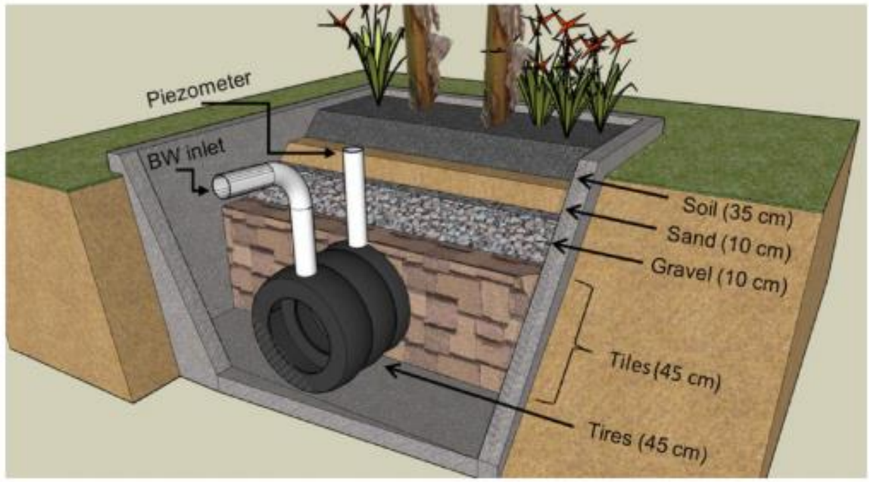


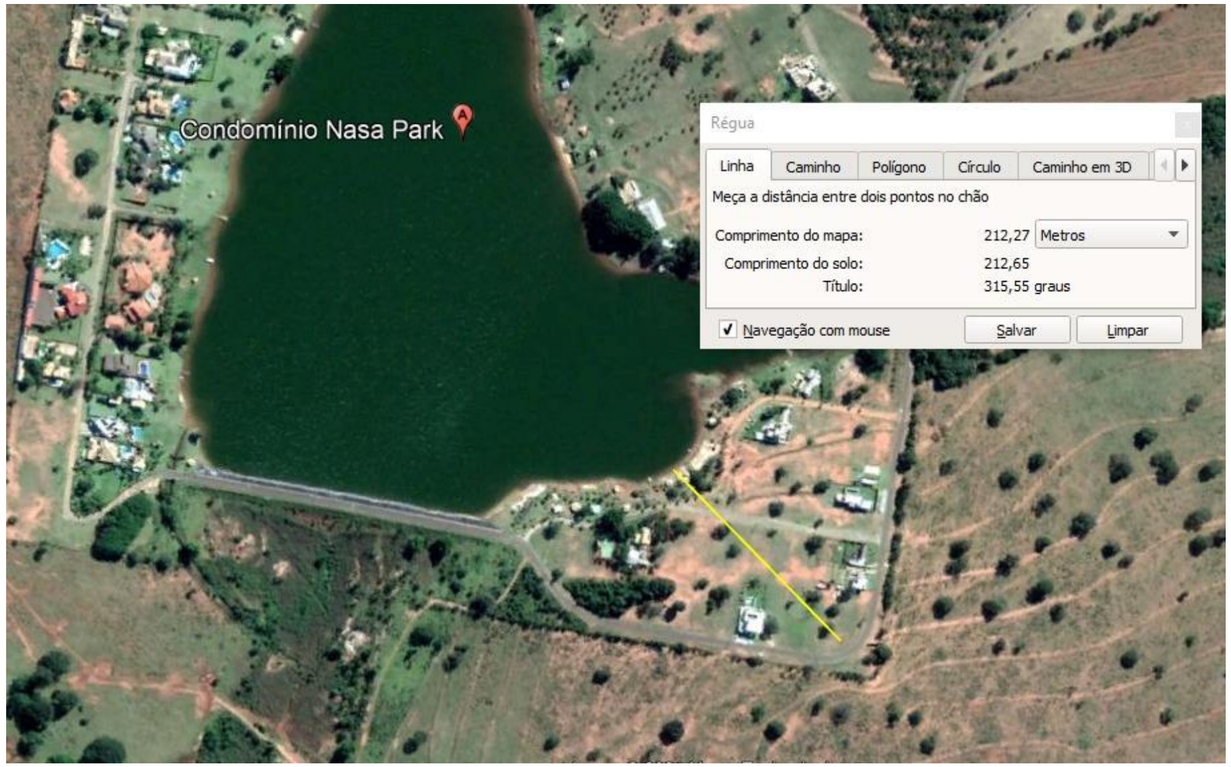
Fig. 1. Cross sectional view of the Evapotranspiration tank (TEvap) showing the different layers of substrate and anaerobic reception chamber (AnC) built with car tires.

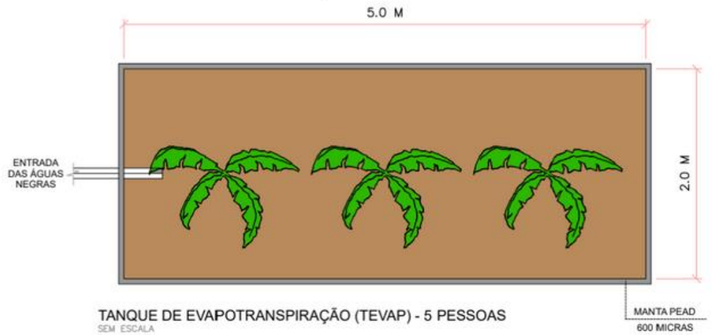
- The full-scale long-term experimental run showed that, considering the specific methanogenic activity of the sludge, the AnC had a capacity to hold a SLR up to 10 times higher than it was submitted.
- Despite the moderate salinity of blackwater during the experimental run (1700 mg·L−1), the highest concentration of salts was measured on top soil layer (2167 mg·L−1) that can be considered **a non-saline soil**.

- **2.4 m2·person−1**;
- **overflow** was observed only when inflow was **higher than 50 L·dia−1**;
- the required area would be 4.8 m2 (2.4 m2·person−1). In other words, 0.8 m2 higher than the built TEvap of 4.0 m2, and 0.8 m2 lower than the calculated using the proposed equation.

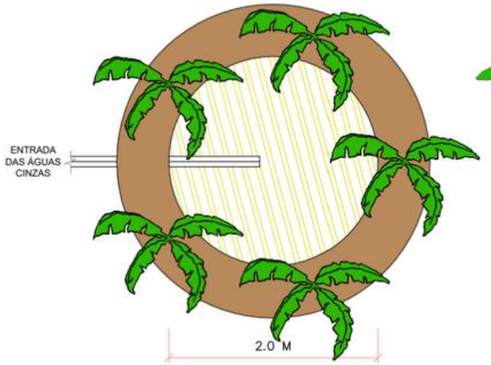
IPÊ
INTELIGÊNCIA EM PROJETOS ECOLÓGICOS

Fonte: Ipê.

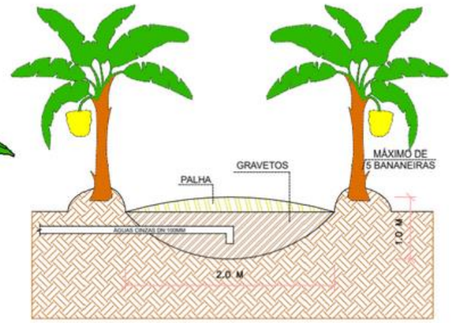




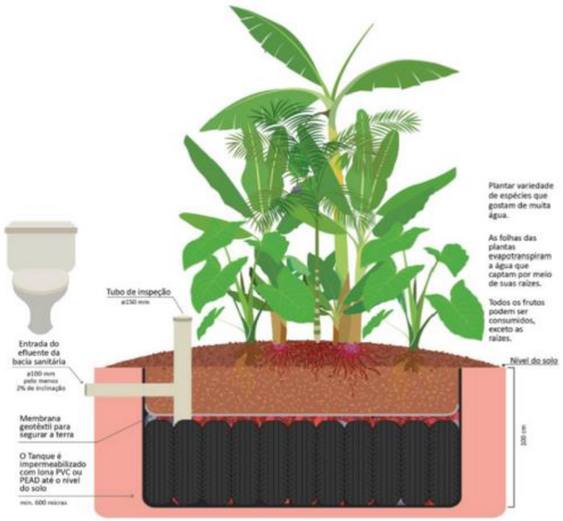
TANQUE DE EVAPOTRANSPIRAÇÃO (TEVAP) - 5 PESSOAS
SEM ESCALA



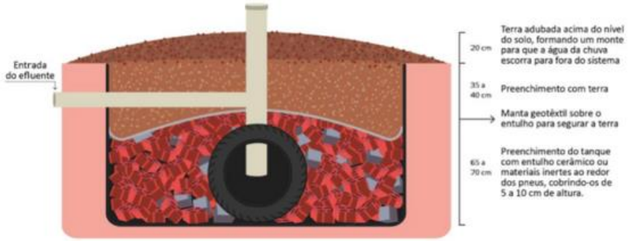
CÍRCULO DE BANANEIRAS - 5 PESSOAS
SEM ESCALA



DETALHE CIRC. BANANEIRAS
SEM ESCALA



DETALHE LONGITUDINAL - TANQUE DE EVAPOTRANSPIRAÇÃO
SEM ESCALA



DETALHE TRANSVERSAL - TANQUE DE EVAPOTRANSPIRAÇÃO
SEM ESCALA

OBSERVAÇÕES:

1- IMPLANTAR TEVAP E CÍRCULO DE BANANEIRAS EM LOCAL DE MAIOR INCIDÊNCIA DE SOL DISPONÍVEL NO LOCAL (NORTE);

2- A MANTA PEAD INDICADA EM PROJETO PODE SER SUBSTITUIDA POR ALVENARIA, DESDE QUE SEJA DIMENSIONADA PARA RESISTIR AOS ESFORÇOS E SEJA IMPERMEABILIZADA;

3- O TEVAP DEVE RECEBER APENAS ÁGUAS NEGRAS (ESGOTO DOS VASOS SANITÁRIOS);

4- O CÍRCULO DE BANANEIRAS DEVE RECEBER APENAS ÁGUAS CINZAS (ESGOTO DAS PIA, CHUVEIRO,MÁQUINA DE LAVAR);

5- OS ÚLTIMOS 30 CM DE TERRA NO TEVAP DEVE SER ADUBADA PARA PLANTIO.

ARAÇOIABA DA SERRA

CLIENTE:	PREFEITURA MUNICIPAL DE ARAÇOIABA DA SERRA	FOLHA:	UNI
PROJETO:	MÓDULO BÁSICO DE SANEAMENTO AMBIENTAL ARAÇOIABA DA SERRA/SP		
ASSUNTO:	PROJETO BÁSICO - TEVAP E CÍRCULO DE BANANEIRA PARA FAMÍLIAS COM ATÉ 5 PESSOAS	REVISÃO:	R02
		DATA:	30/04/2024
SETOR:	SECRETARIA DE OBRAS PÚBLICAS — ENGENHEIRO: ADENILSON PALMA	ESCALA:	INDICADA

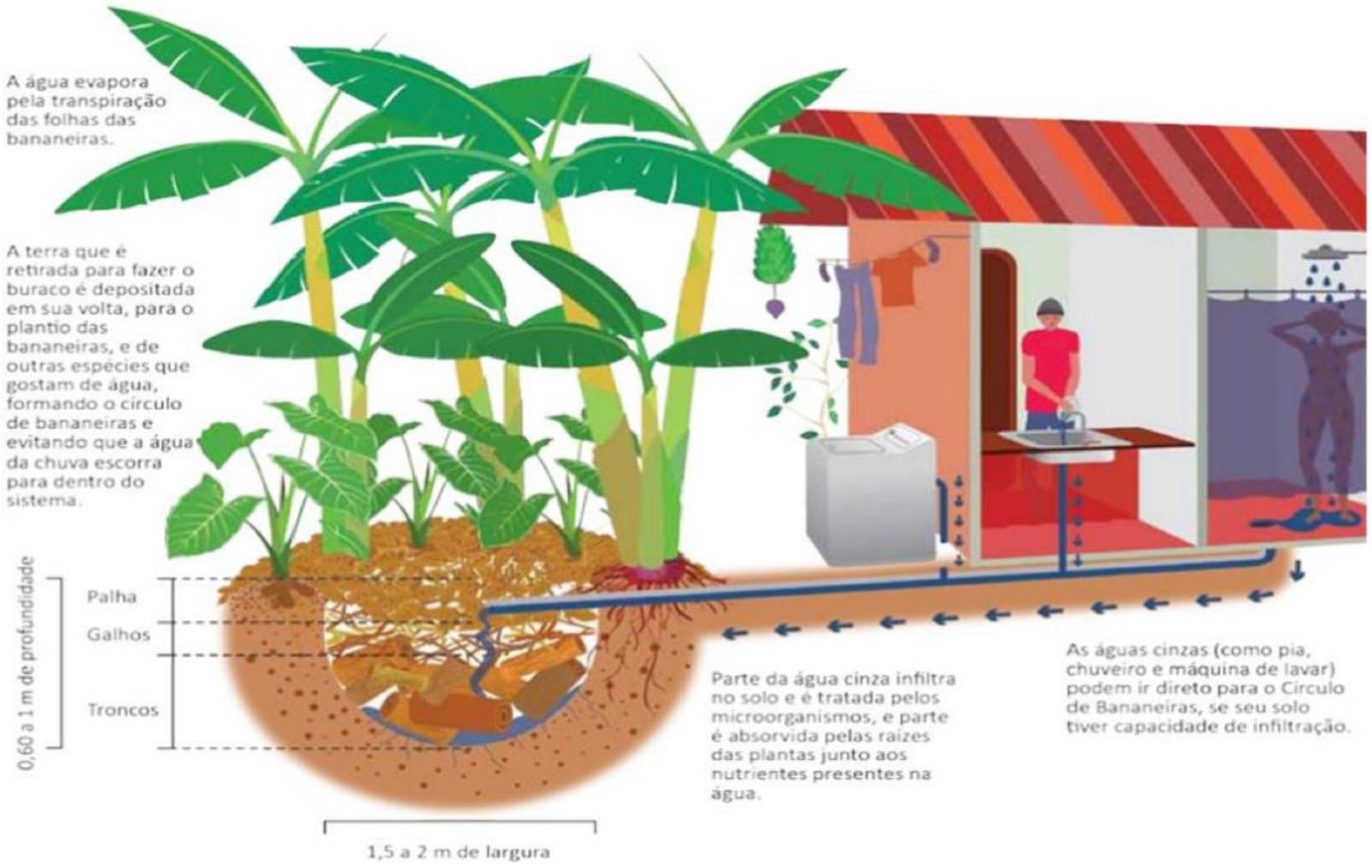
PREFEITURA
ARAÇOIABA DA SERRA

APOSTILA DE SANEAMENTO ECOLÓGICO

Tanque de Evapotranspiração

Araçoiaba da Serra

2024



Fonte: Ilustração de Patrícia Yamamoto para a cartilha do Instituto de Projetos e Pesquisas Socioambientais - IPESA.

PREFEITURA
ARAÇOIABA DA SERRA

APOSTILA DE SANEAMENTO ECOLÓGICO
CÍRCULO DE BANANEIRAS

Araçoiaba da Serra
2024

594900.0
595200.0
595500.0
OSAICO 5 CM/PIXEL (11.04.2023)
Globe Satellite

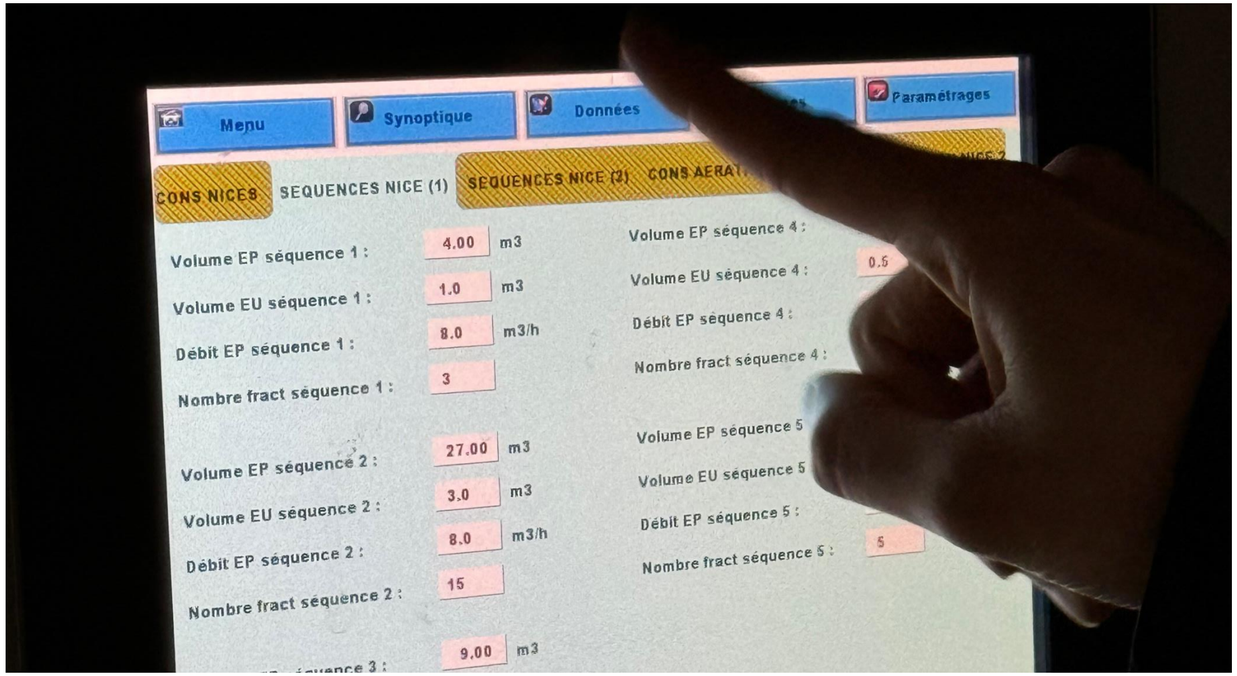
F-Q
Centrífugas
FBAS
Adensador de lodo
UASB

AARHUS
UNIVERSITY

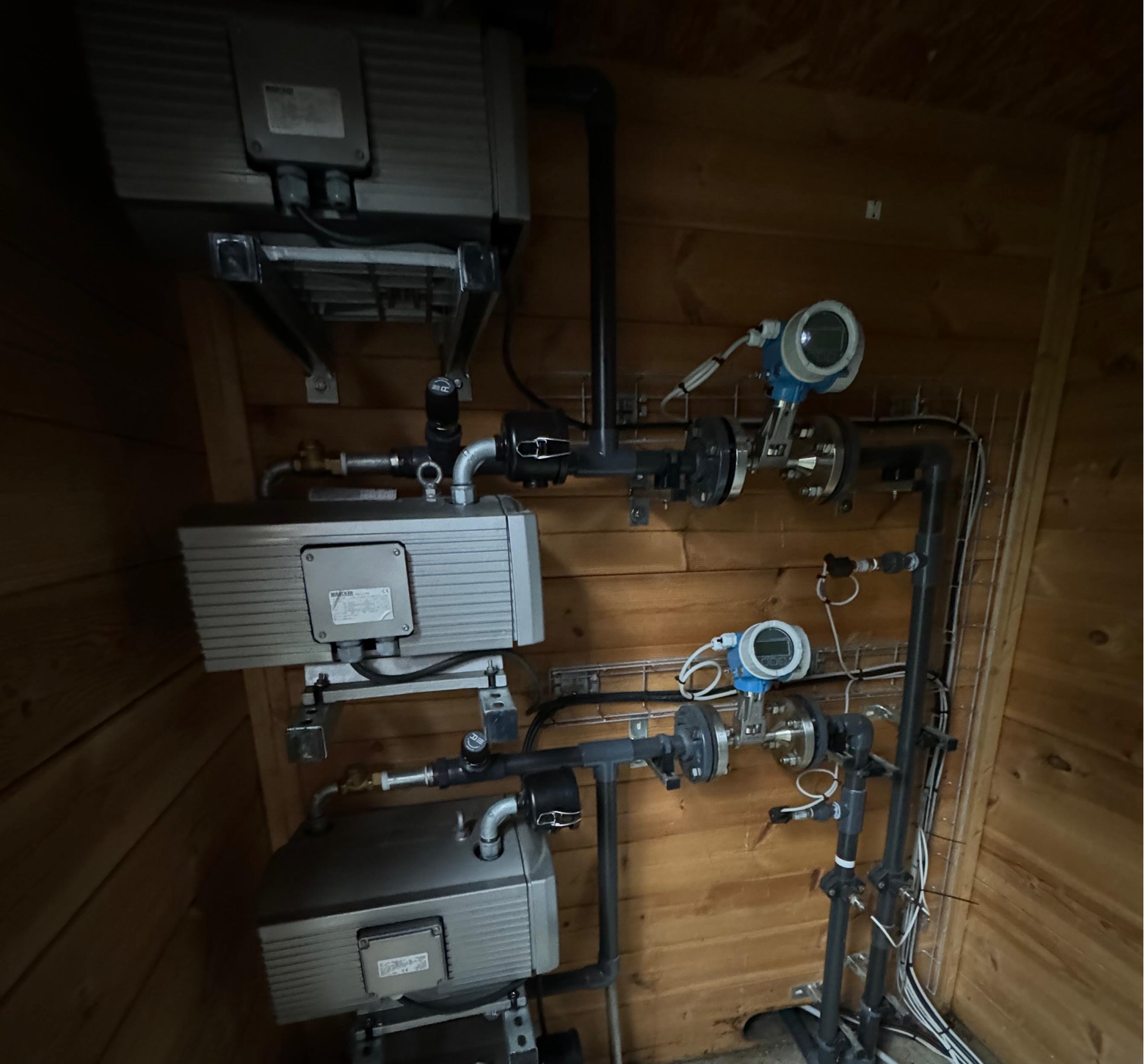
AARHUS
UNIVERSITY

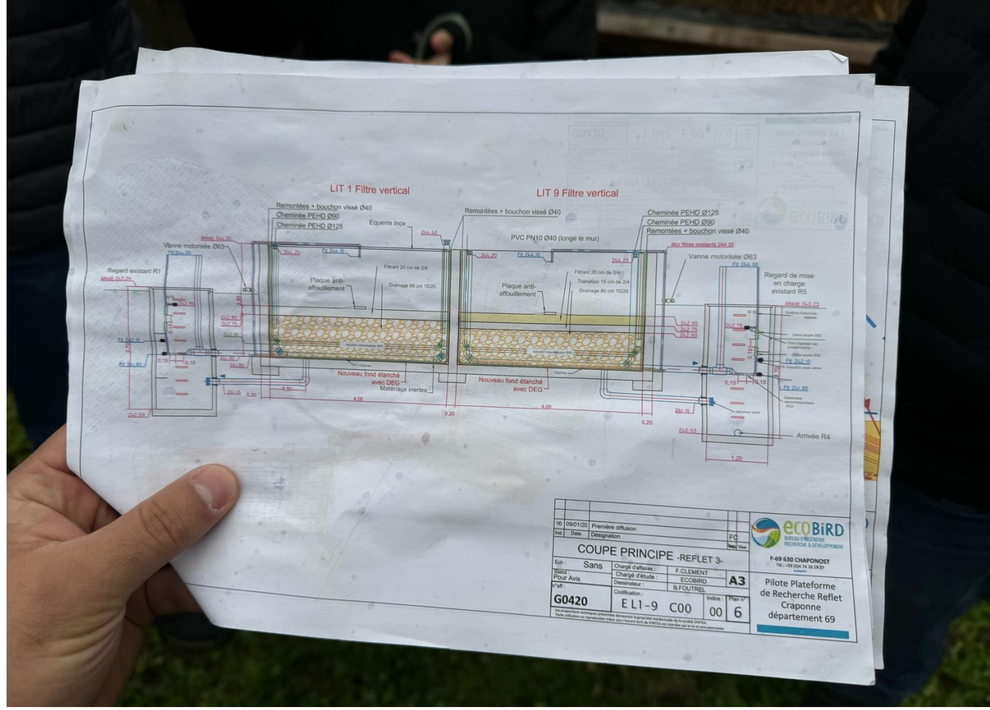
AARHUS
UNIVERSITY

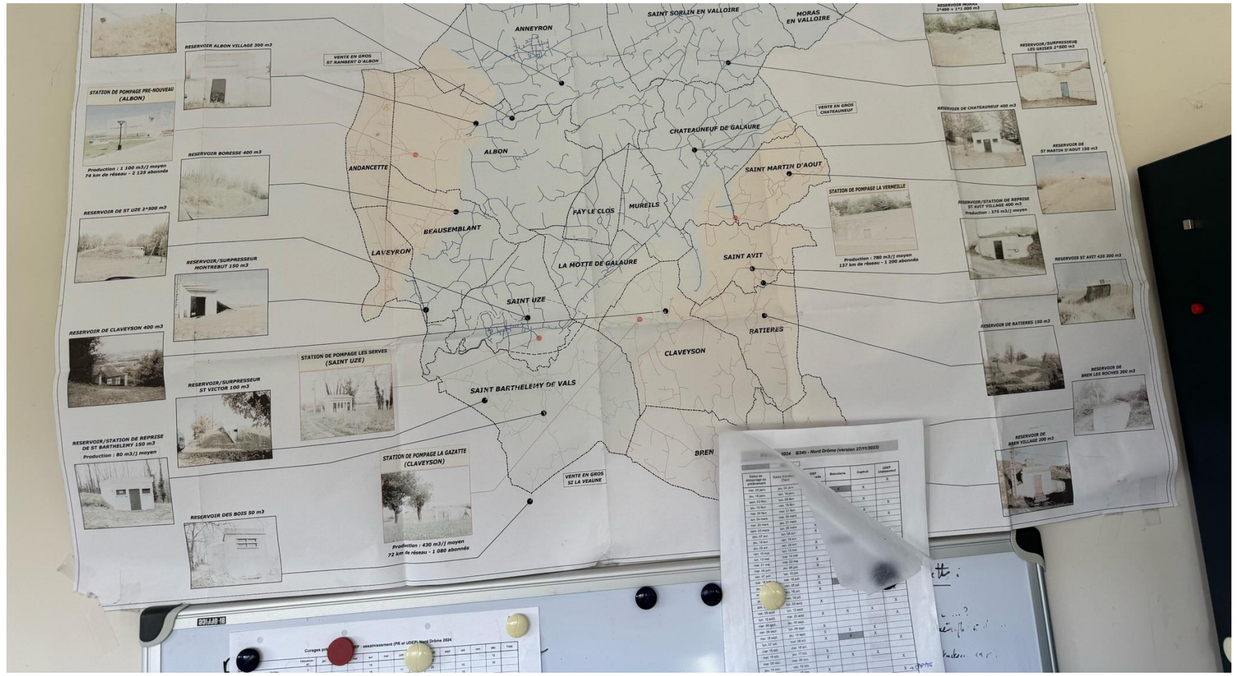
Universidad Tecnológica
de Pereira


Menu
Synoptique
Données
Paramétrages
CONS NICES
SEQUENCES NICE (1)
SEQUENCES NICE (2)
Volume EP séquence 1 : 4.00 m3
Volume EU séquence 1 : 1.0 m3
Débit EP séquence 1 : 8.0 m3/h
Nombre fract séquence 1 : 3
Volume EP séquence 2 : 27.00 m3
Volume EU séquence 2 : 3.0 m3
Débit EP séquence 2 : 8.0 m3/h
Nombre fract séquence 2 : 15
9.00 m3
Volume EP séquence 4 :
Volume EU séquence 4 : 0.5
Débit EP séquence 4 :
Nombre fract séquence 4 :
Volume EP séquence 5
Volume EU séquence 5
Débit EP séquence 5 :
Nombre fract séquence 5 : 5

INRAE

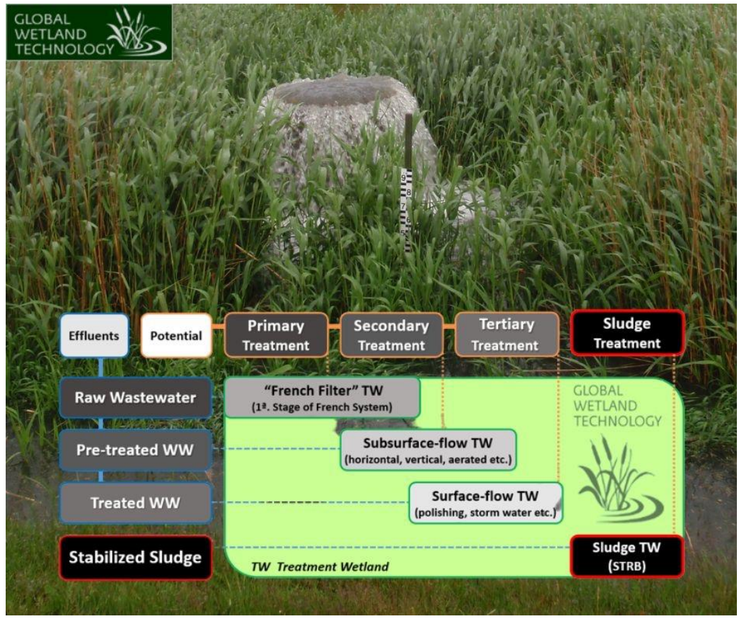


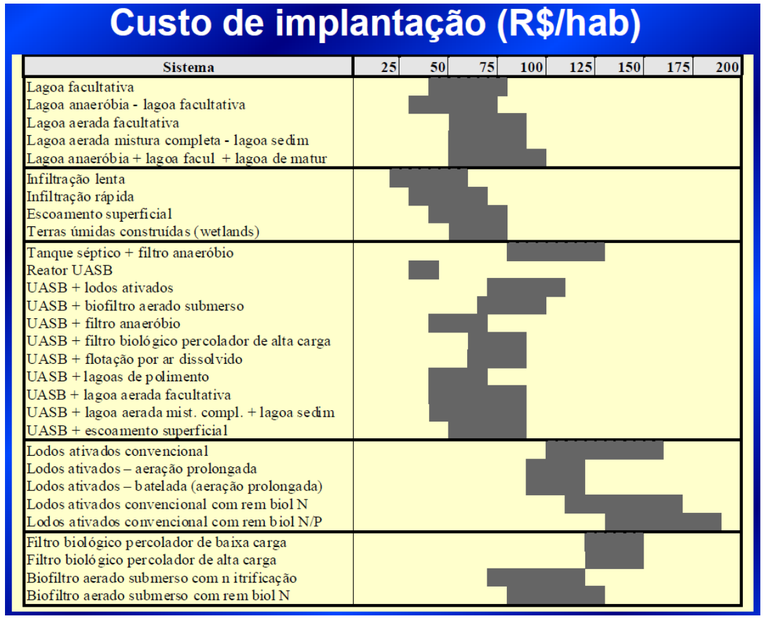

LIT 1 Filtre vertical
LIT 9 Filtre vertical
COUPE PRINCIPE -REFLET 3-
ecoBiRD
Pilote Plateforme de Recherche Reflet Craponne département 69
G0420
A3

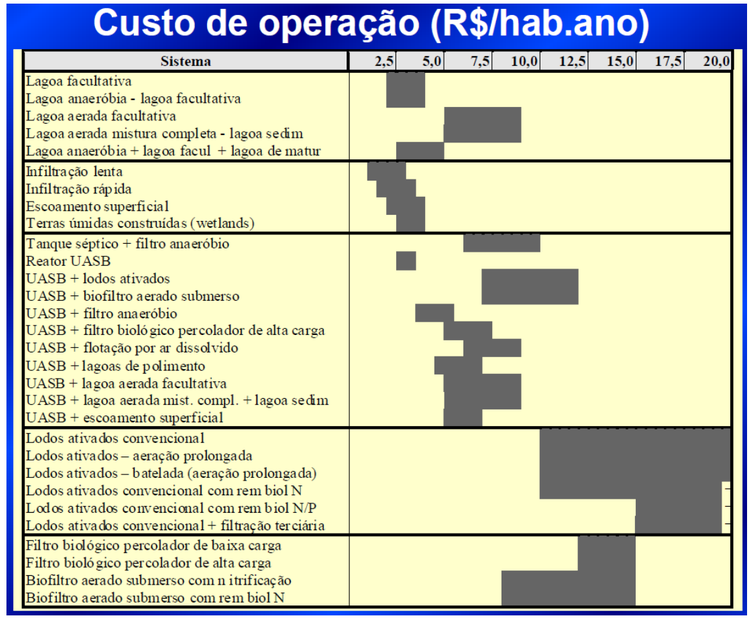

ANNEYRON
SAINT SORLIN EN VALLOIRE
MORAS EN VALLOIRE
CHATEAUNEUF DE GALAURE
ALBON
ANDANCETTE
SAINT MARTIN D'AOUT
MUREILS
PAY LE CLOS
BEAUSEMBLANT
LAVEYRON
LA MOTTE DE GALAURE
SAINT AVIT
SAINT UZE
RATIERES
CLAVEYSON
SAINT BARTHELEMY DE VALS
BREN
STATION DE POMPAGE PRE-NOUVEAU (ALBON)
RESERVOIR ALBON VILLAGE 300 m3
RESERVOIR BORESSE 400 m3
RESERVOIR DE ST UZE 2*500 m3
RESERVOIR/SURPRESSEUR MONTREBUT 150 m3
RESERVOIR DE CLAVEYSON 400 m3
RESERVOIR/SURPRESSEUR ST VICTOR 100 m3
STATION DE POMPAGE LES SERVES (SAINT UZE)
RESERVOIR/STATION DE REPRISE DE ST BARTHELEMY 150 m3
Production : 80 m3/j moyen
STATION DE POMPAGE LA GAZATTE (CLAVEYSON)
Production : 430 m3/j moyen
72 km de réseau - 1 080 abonnés
RESERVOIR DES BOIS 50 m3
VENTE EN GROS ST RAMBERT D'ALBON
VENTE EN GROS CHATEAUNEUF
VENTE EN GROS SI LA VEAUNE
STATION DE POMPAGE LA VERNEILLE
Production : 780 m3/j moyen
137 km de réseau - 1 320 abonnés
RESERVOIR/STATION DE REPRISE ST AVIT VILLAGE 400 m3
Production : 375 m3/j moyen
RESERVOIR/SURPRESSEUR LES GRIVES 2*500 m3
RESERVOIR DE CHATEAUNEUF 400 m3
RESERVOIR DE ST MARTIN D'AOUT 150 m3
RESERVOIR ST AVIT 420 200 m3
RESERVOIR DE RATIERES 150 m3
RESERVOIR DE BREN LES ROCHES 300 m3
RESERVOIR DE BREN VILLAGE 200 m3

Principe
Les boues (matières de vidange) issues de fosses septiques ou toutes eaux doivent être traitées avant d'être épandues sur les terres agricoles ou dirigées vers une autre filière. Les matières de vidange déposées sur site, après un prétraitement aérobie (bassin d'aération) sont dirigées vers les lits de séchage plantés de roseaux (LSPR). Les percolats ou jus récupérés en sortie des lits sont traités sur un filtre complémentaire (étage 2) avant d'être réutilisé en irrigation (épandage sur 5 ha).
Carte d'identité de la station
Date de mise en service : 2003
Secteur collecté : Nord-Est du département Tarn et Garonne
Capacité de traitement : 3900 fosses/an (11 000 m³/an soit 131 tonts/an)
Volume du bassin de stockage aéré : 180 m³
Déshydratation et minéralisation des boues par LSPR
surface totale de 2600 m² subdivisée en 8 bassins de 325m² chacun
Un traitement de finition par filtre planté de roseaux
surface totale de 100 m², subdivisée en deux filtres de 50 m²
Épandage sur plantation en taillis courte rotation (TCR) des percolats sur 5 ha plantés de peupliers et d'eucalyptus par micro-irrigation.
Le rôle des roseaux
Action mécanique (racines et rhizosphère) évitant le colmatage du filtre par l'accumulation de la couche de boues.
Déshydratation (suivant du dépôt de boues par évapotranspiration, le roseau jouant un rôle similaire à une pompe.
Aide au maintien d'une bonne aération du dépôt de boues nécessaire à la minéralisation (effet rhizosphère).
Vidange des boues
Local technique
Bassin de stockage aéré
ÉTAGE 1
ÉTAGE 2
Légende des couleurs
Aire et borne de dépotage
Local technique
Bassin de stockage aéré
Étage 1
Étage 2
Bassin de stockage des percolats
Local de pompage et filtration complémentaire
Grontmij

Configurações, CAPEX e OPEX (TOTEX)







Source: Global Wetland and von Sperling.

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1896
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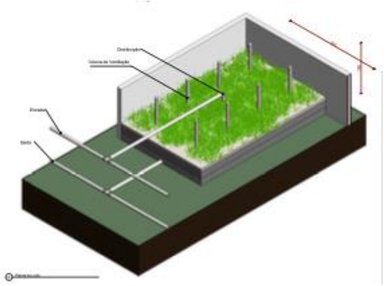
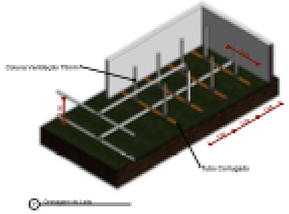
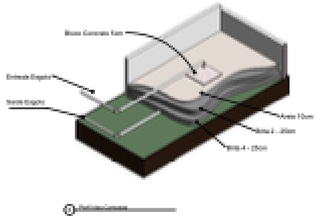
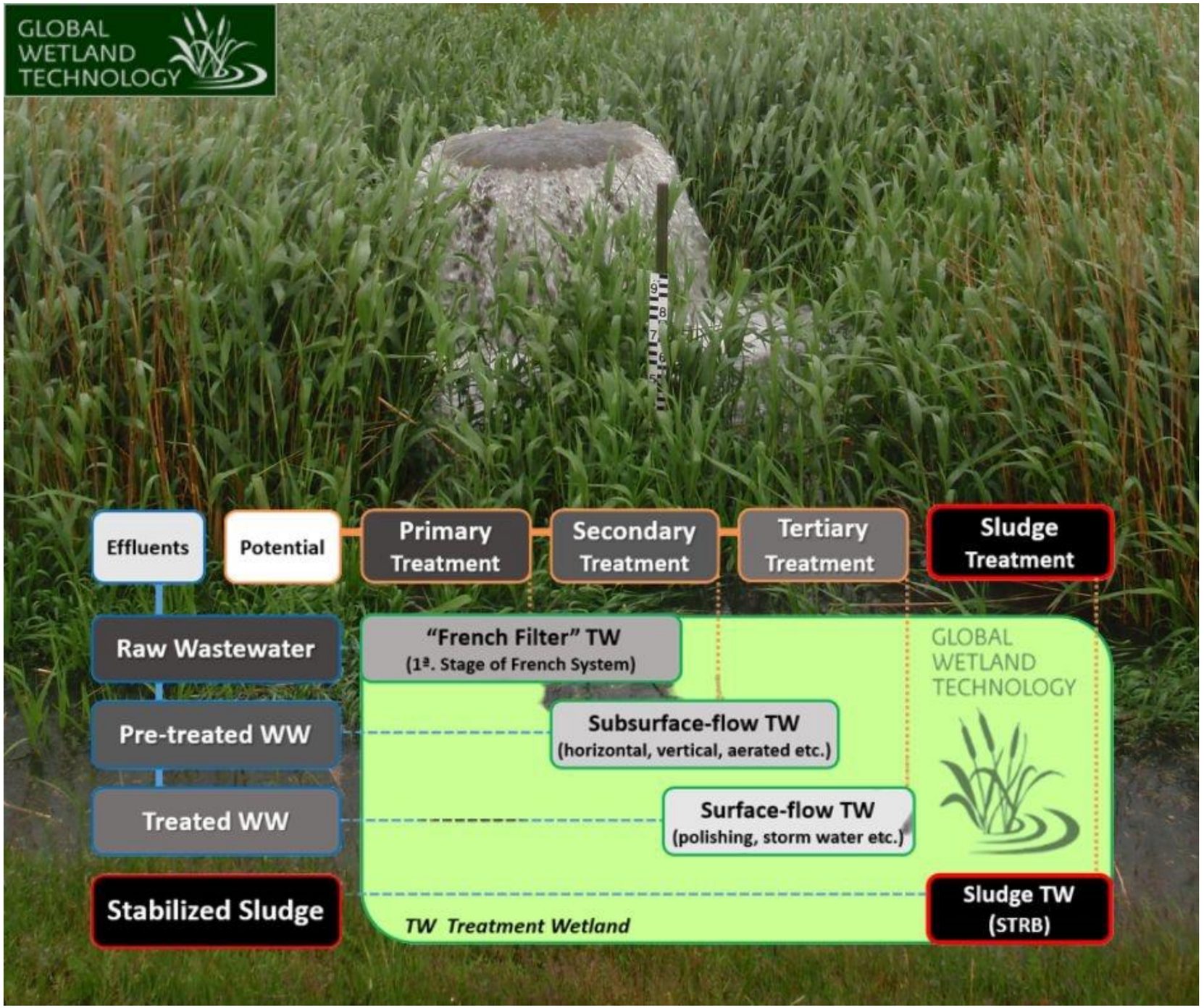
Source: Magalhães Filho.









Source: Global Wetland.

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Aspectos construtivos

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UFRGS

Source: UFSC.

"VULNERABILIDADE DE DILUIÇÃO HÍDRICA" (VDH)

Cenário proposto - Estudo de Caso

Arroio Dilúvio, Porto Alegre, RS

Passo 1:
Classe do corpo hídrico: Classe II

Passo 2:
Concentração máxima de DBO5: 5 mg/L
Obs.: para o estudo foi analisado apena DBO5.

Passo 3:
Padrão de vazão de permanência:

Bacia hidrográfica	Local	Padrão da vazão de referência	Vazão específica ($m^3.s^{-1}.km^{-2}$)	
			Área de drenagem superior a 10 km²	Área de drenagem até 10 km²
Lago Guaíba	Arroio Dilúvio	Q_{90}	0,00526	0,00286

Passo 4:
Eficiência: 60% (TS+FAN) e 90% (TS+WCFHS)

Q_{rio}: vazão do corpo de água em ($m^3.s^{-1}$);
Q_{esgoto}: vazão do efluente ($m^3.s^{-1}$);
C_{rio}: concentração de DBO_5 do corpo de água (DBO_{rio});
C_{esgoto}: concentração de DBO_5 do efluente.

Passo 5:
RD = RD = Qrio / Qesg
MEM = ((Qrio x Crio) + (Qesgoto x Cesgoto)) / (Qrio +Qesgoto)

Passo 6:
Habitantes = Qefl / Qcontribuição

Tecnologias adaptadas ao Brasil

NORMA BRASILEIRA

ABNT NBR 17076

Primeira edição
26.04.2024

Projeto de sistema de tratamento de esgoto de menor porte — Requisitos

Design Small domestic wastewater treatment systems — Requirements

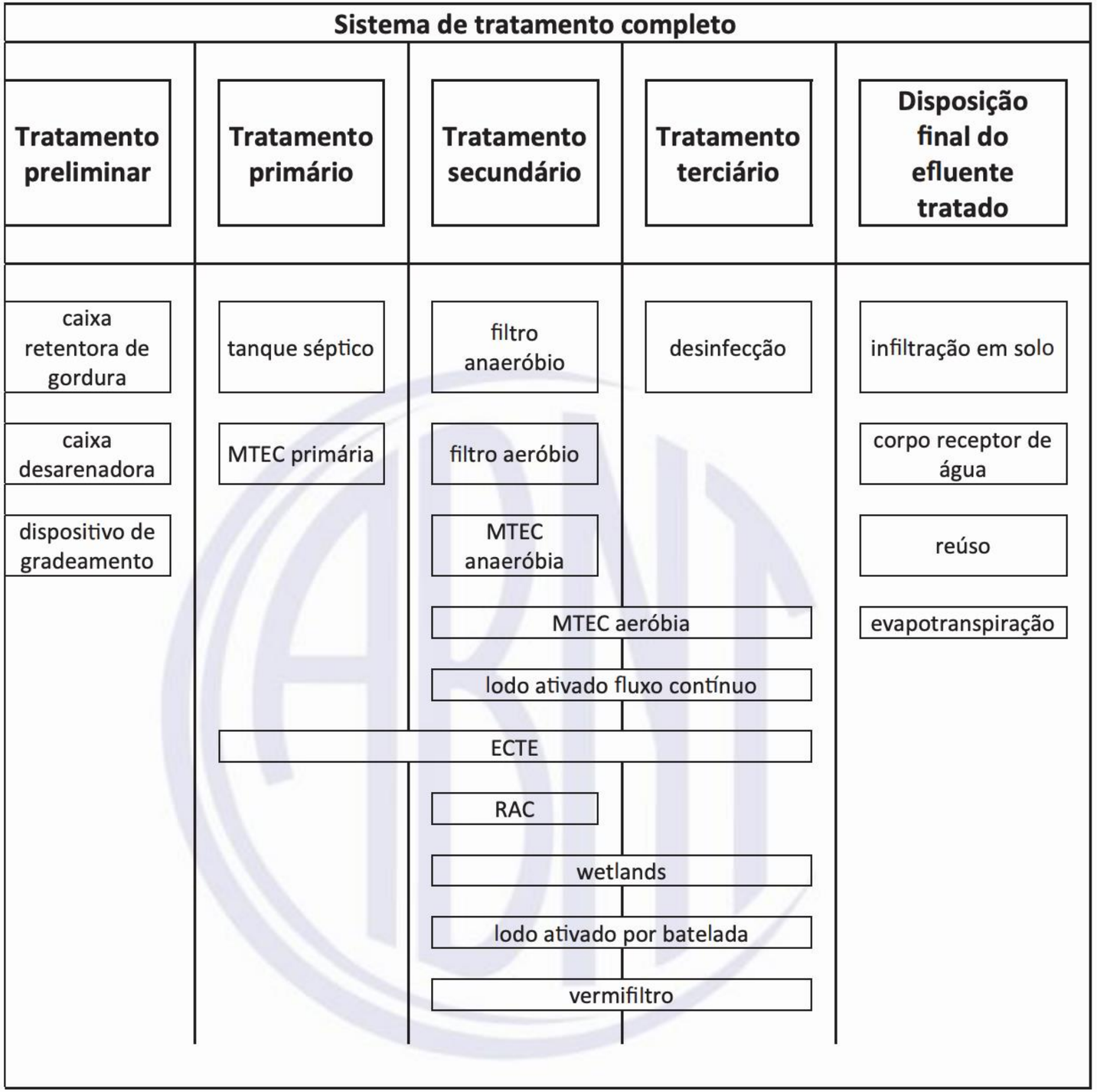
Anexo H (normativo) ***Wetlands* construídos** .....
H.1 **Generalidades** .....
H.2 **Dimensionamento** .....
H.2.3 ***Wetlands* de fluxo horizontal** .....
H.2.4 ***Wetlands* de fluxo vertical** .....
H.3 **Detalhes construtivos** .....
H.4 **Dispositivos de entrada e saída** .....
H.5 **Operação** .....
Anexo I (normativo) **Vermifiltro** .....
I.1 **Generalidades** .....
I.2 **Dimensionamento** .....
I.3 **Detalhes construtivos do vermifiltro** .....
I.4 **Operação** .....
Anexo M (normativo) **Disposição final do efluente líquido tratado em tanque de evapotranspiração** .....
M.1 **Generalidades** .....
M.2 **Dimensionamento do tanque de evapotranspiração** .....
M.3 **Processo construtivo** .....
M.3.1 **Estanqueidade e impermeabilização do fundo e das paredes** .....
M.3.2 **Os dispositivos de entrada, de distribuição do efluente e de saída** .....
M.3.3 **Materiais de enchimento** .....
M.4 **Águas pluviais** .....
M.5 **Plantas de superfície** .....
M.6 **Instalação e manutenção do tanque** .....

ICS 91.140.70; 91.140.80

ISBN 978-85-07-10128-4

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS

Número de referência
ABNT NBR 17076:2024
92 páginas



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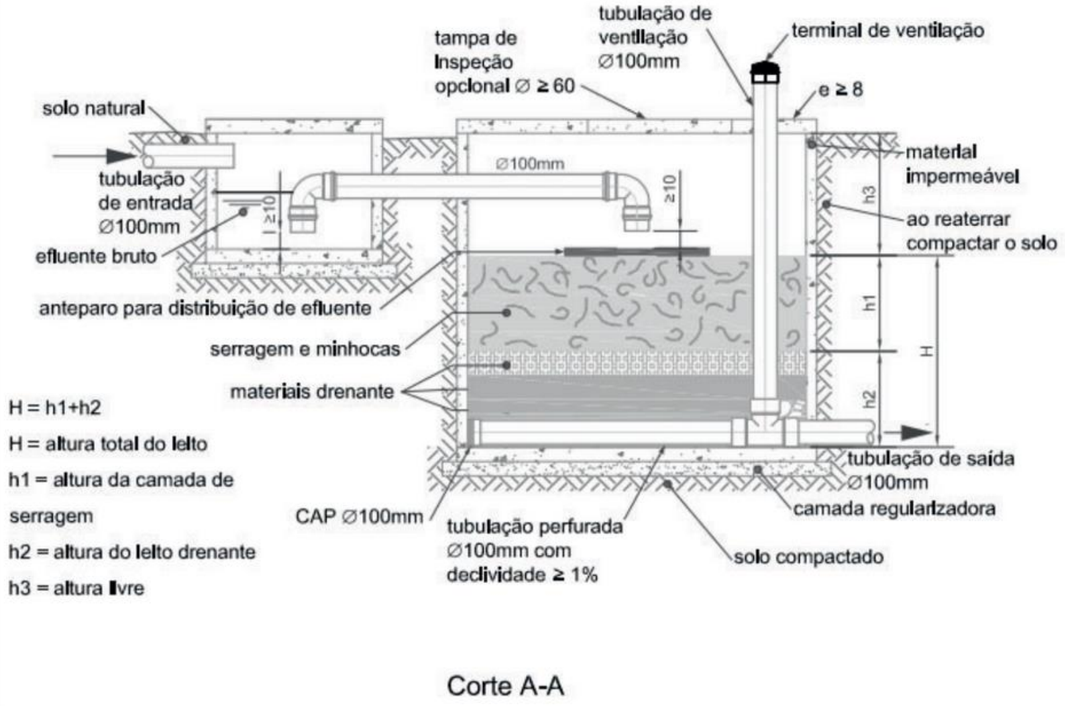


Figura I.1 – Esquema representativo do vermifiltro

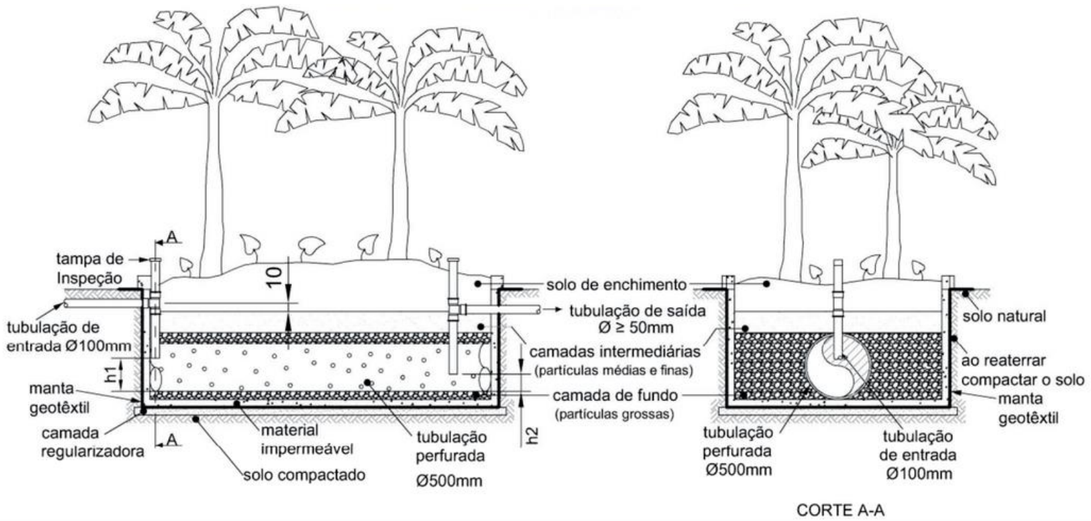


Figura M.1 – Esquema representativo de um tanque de evapotranspiração

Presidência da República
Casa Civil
Secretaria Especial para Assuntos Jurídicos

LEI Nº 14.904, DE 27 DE JUNHO DE 2024

Estabelece diretrizes para a elaboração de planos de adaptação à mudança do clima; altera a Lei nº 12.114, de 9 de dezembro de 2009; e dá outras providências.

Art. 2º São diretrizes dos planos de adaptação à mudança do clima:

I - a identificação, a avaliação e a priorização de medidas para enfrentar os desastres naturais recorrentes e diminuir a vulnerabilidade e a exposição dos sistemas ambiental, social, econômico e de infraestrutura, em áreas rurais e urbanas, bem como os efeitos adversos atuais e esperados das mudanças do clima nos âmbitos local, municipal, estadual, regional e nacional;

II - a gestão e a redução do risco climático diante dos efeitos adversos da mudança do clima, de modo a estimar, minimizar ou evitar perdas e danos e planejar e priorizar a gestão coordenada de investimentos, com base no grau de vulnerabilidade, conforme definido pela PNMC;

III - o estabelecimento de instrumentos de políticas públicas econômicos, financeiros e socioambientais que assegurem a viabilidade e a eficácia da adaptação dos sistemas ambiental, social, econômico e de infraestruturas críticas;

IV - a integração entre as estratégias de mitigação e adaptação nos âmbitos local, municipal, estadual, regional e nacional, em alinhamento com os compromissos assumidos no Acordo de Paris sob a Convenção-Quadro das Nações Unidas sobre Mudança do Clima, por meio da Contribuição Nacionalmente Determinada;

V - o estabelecimento de prioridades com base em setores e regiões mais vulneráveis, a partir da identificação de vulnerabilidades, por meio da elaboração de estudos de análise de riscos e vulnerabilidades climáticas;

VI - a sinergia entre a Política Nacional de Proteção e Defesa Civil (PNPDEC), instituída pela Lei nº 12.608, de 10 de abril de 2012, o Plano Nacional de Proteção e Defesa Civil, os planos estaduais, distrital e municipais de proteção e defesa civil e a Estratégia Nacional de Segurança de Infraestruturas Críticas;

VII - o estímulo à adaptação do setor agropecuário ao Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura (Plano ABC), vinculado ao investimento em pesquisa, desenvolvimento e inovação ou em práticas, processos e tecnologias ambientalmente adequadas e economicamente sustentáveis;

VIII - a adoção de soluções baseadas na natureza como parte das estratégias de adaptação, considerando seus benefícios adicionais e sua capacidade de integrar resultados para adaptação e mitigação, simultaneamente;

IX - o monitoramento e a avaliação das ações previstas, bem como a adoção de processos de governança inclusivos para a revisão dos planos de que trata esta Lei a cada 4 (quatro) anos, orientada pelo ciclo dos planos plurianuais;

X - a promoção de pesquisa, desenvolvimento e inovação orientados:

Artigos técnicos

Links:

Resolução ANA 245, NR 12/2025:

https://www.linkedin.com/posts/fernandojcmf_insights-sobre-o-setor-de-drenagem-e-manejo-activity-7323454601217622016-mouu?utm_source=share&utm_medium=member_desktop&rcm=ACoAAAZ_LtgB_ueajaak0hMB948F9_WwqrdJwsA

https://www.linkedin.com/posts/fernandojcmf_um-pouco-sobre-a-resolu%C3%A7%C3%A3o-ana-no-245-na-activity-7311036744164896769-fTPi?utm_source=share&utm_medium=member_desktop&rcm=ACoAAAZ_LtgB_ueajaak0hMB948F9_WwqrdJwsA

fluxo

Rotária do Brasil

ECCLO

ecotelhado
DESIGN BIOFÍLICO

phytorestore brasil®
água / solo / ar
jardins filtrantes

Considerações finais

Habitação como premissa para uma infraestrutura urbana sustentável

Meta 1

Economia-Social-Ambiental.
Cases com **modelo de negócio** sustentável, pautados por **ACV** e ferramentas de **viabilidade**.

Meta 2

Atenção para **Normativas, guias, ferramentas e Políticas** - tratamento e reúso.

Meta 3

Produtos específicos para cada **tipo de ator, contexto e cenário**.
Tecnologia / Gestão.

Público-alvo

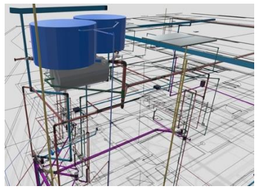
Produtos com enfoque para cada tipo de público.

Arquitetura e Urbanismo #1

Projetos Arquitetônicos
e de Urbanismo.

Construção Civil #2

Hidrossanitário
Infraestrutura Urbana



Sociedade #3

Municípios e Prestadores.

OBRIGADO!

INCT SbN

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Membro INCT SbN

CNPq

FAPERGS
Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul

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