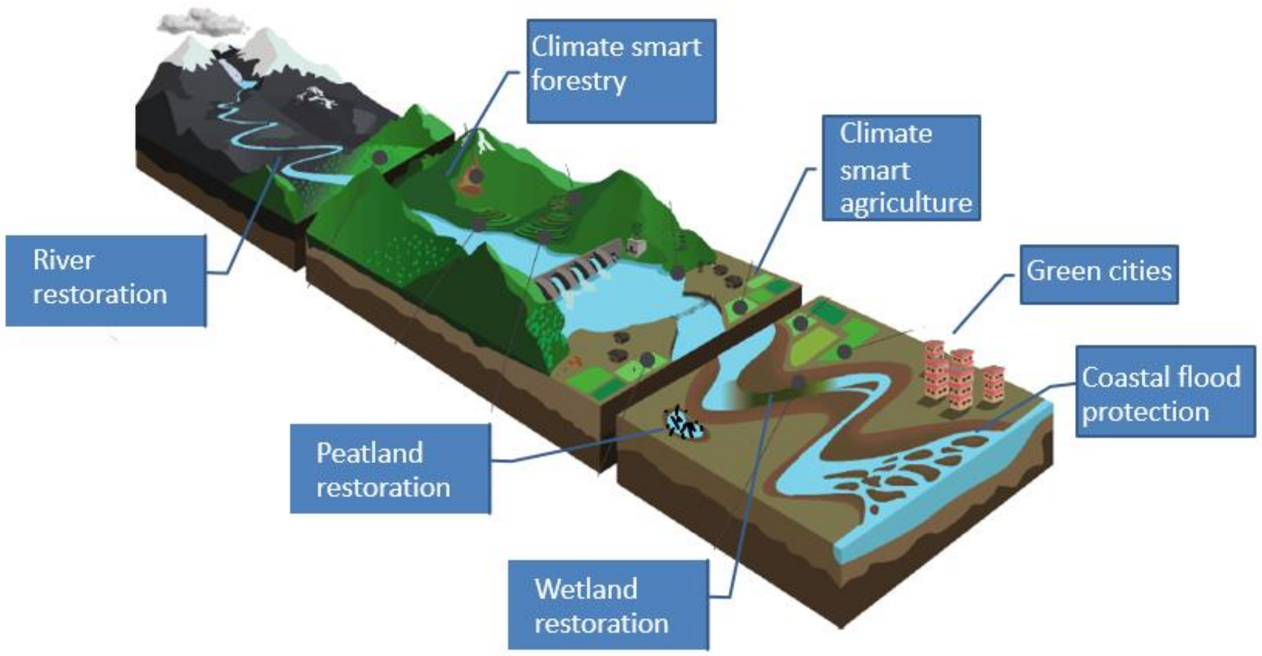
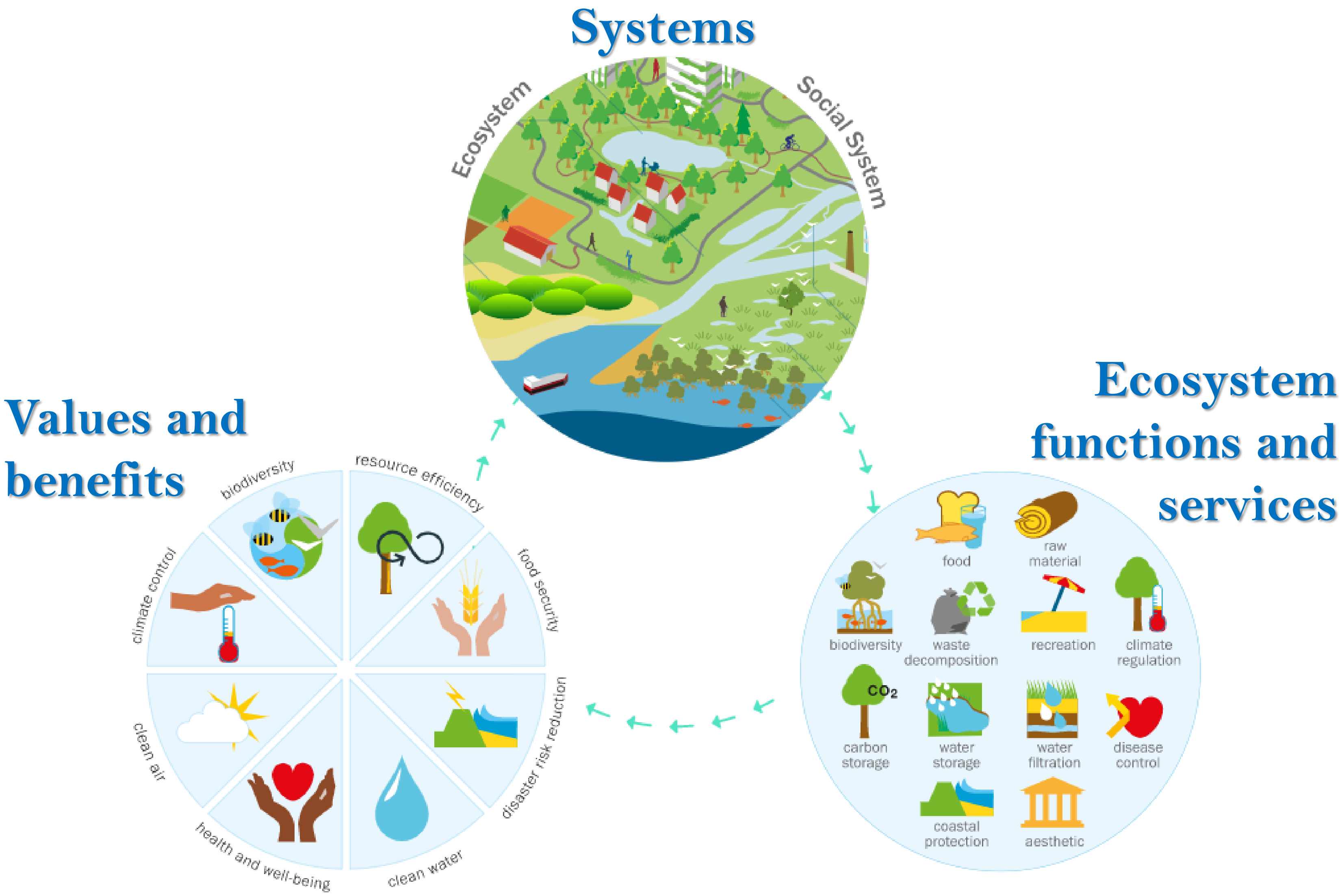
Asian Institute of Technology

# Introduction to Nature-based Solutions




Professor Rajendra P. Shrestha
Asian Institute of Technology

# Values and benefits of Natural capitals

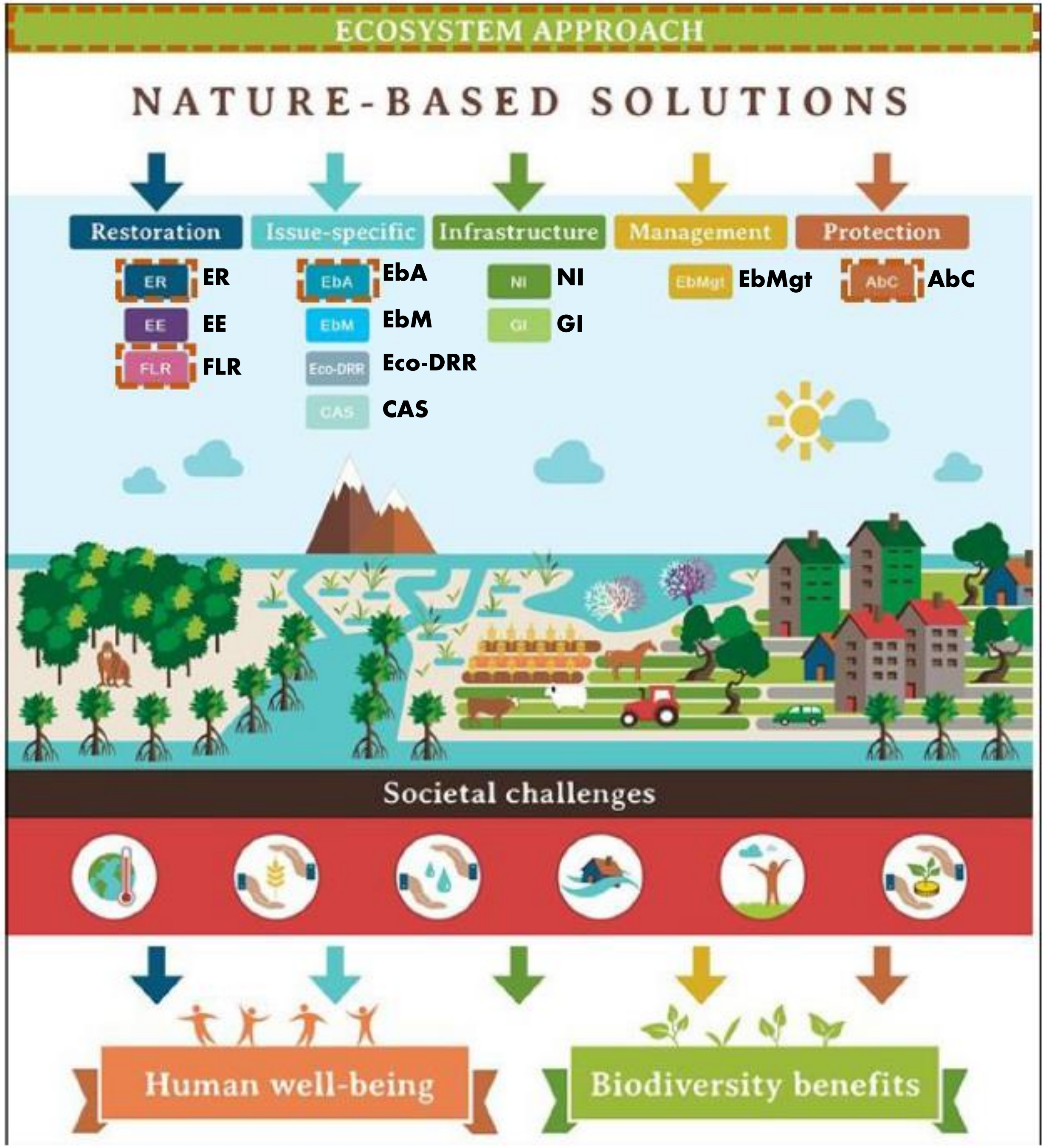


# Approaches in Nature management

- Landscape approach
- Watershed management
- Sustainable agriculture
- Ecological intensification
- Climate-smart agriculture
- Functional landscape /agrobiodiversity
- Sustainable land management
- Etc.

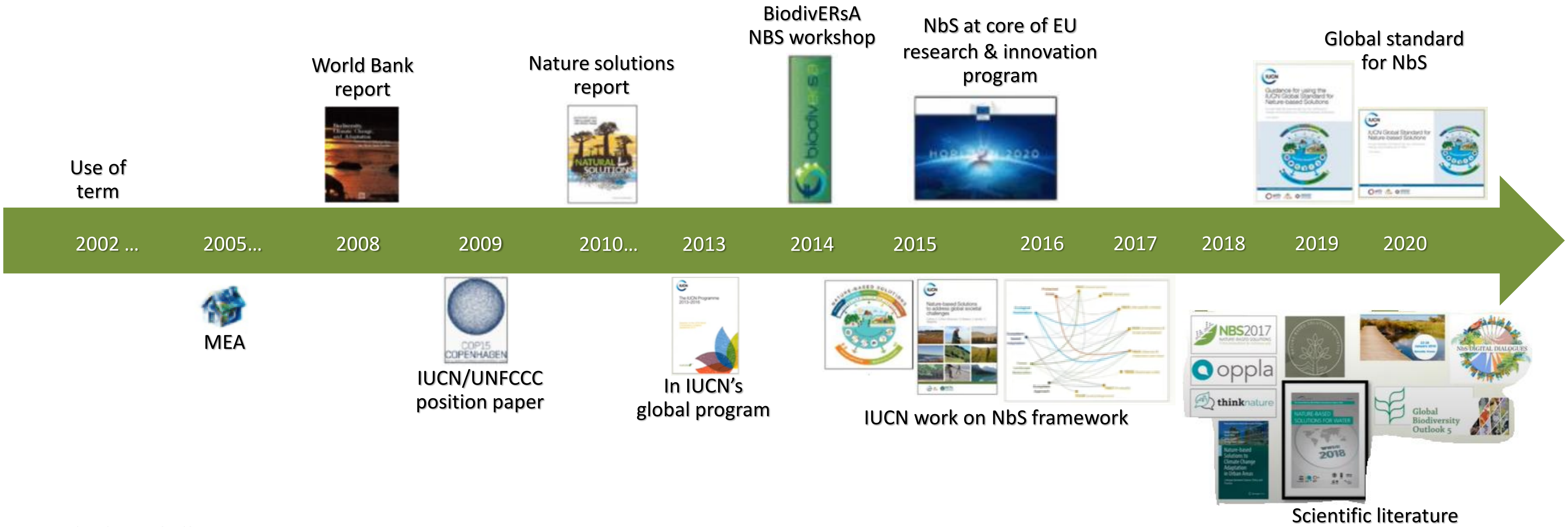
# Even more terms used in Nature management or under Nature-based solutions (NbS) umbrella

ER= Ecological Restoration
EE = Ecological Engineering
FLR = Forest Landscape Restoration
EbA = Ecosystem-based Adaptation
EbM = Ecosystem-based Mitigation
Eco-DRR = Ecosystem-based Disaster Risk Reduction
CAS = Climate Adaptation Services
NI = Natural Infrastructure
GI – Green Infrastructure
EbMgt: Ecosystem-based Management
AbC = Area-based Conservation




*Cited in Cohen-Shacham et al., 2019*

# Evolution of NbS




*Modified from IUCN/CEM, 2020*

# What is NbS?

- are "actions inspired by, supported by or copied from nature; both using and enhancing existing solutions to challenges, as well as exploring more novel solutions"
  - for example, mimicking how non-human organisms and communities cope with environmental extremes." *(EEA, 2015)*
- measures that protect, sustainably manage to restore nature, with the goal of maintaining or enhancing ecosystem services to address societal changes

# Principles of NbS

- embrace nature conservation norms (and principles);
- can be implemented alone or in an integrated manner with other solutions to societal challenges (e.g. technological and engineering solutions);
- are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge;
- produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation;
- maintain biological and cultural diversity and the ability of ecosystems to evolve over time;
- are applied at a landscape scale;
- recognise and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystems services; and
- are an integral part of the overall design of policies, and measures or actions, to address a specific challenge


Sowi ń ska- Ś wierkosz and García, 2022
https://doi.org/10.1016/j.nbsj.2022.100009

# Global standards for NbS

## Criteria

- NbS effectively address societal challenges
- Design of NbS is informed by scale
- NbS result in a net gain to biodiversity and ecosystem integrity
- NbS are economically viable
- NbS are based on inclusive, transparent and empowering governance processes
- NbS equitably balance trade-offs between achievement of their primary goal(s) and the continued provision of multiple benefits
- NbS are managed adaptively, based on evidence

*IUCN, 2020*

# NbS Application

- NbS use the features and complex system processes of nature, such as its ability to store carbon and regulate water flows
- Can be applied in any sector
  - NbS to climate change "Using natural (not man-made) - techniques to either prevent, mitigate or adapt to the effects of climate change. For example, green roofs to reduce the atmospheric heating effects of buildings; re-planting coastal areas with native plants."
- Application of NbS framework requires consideration of scale and time particularly how to best spatially and temporally
  - select and sequence what and how to intervene to generate positive biophysical interactions and social benefits in and between ecosystems
  - sustainably expand connectivity of positive interactions

# NbS Activities and Benefits

## In Agriculture

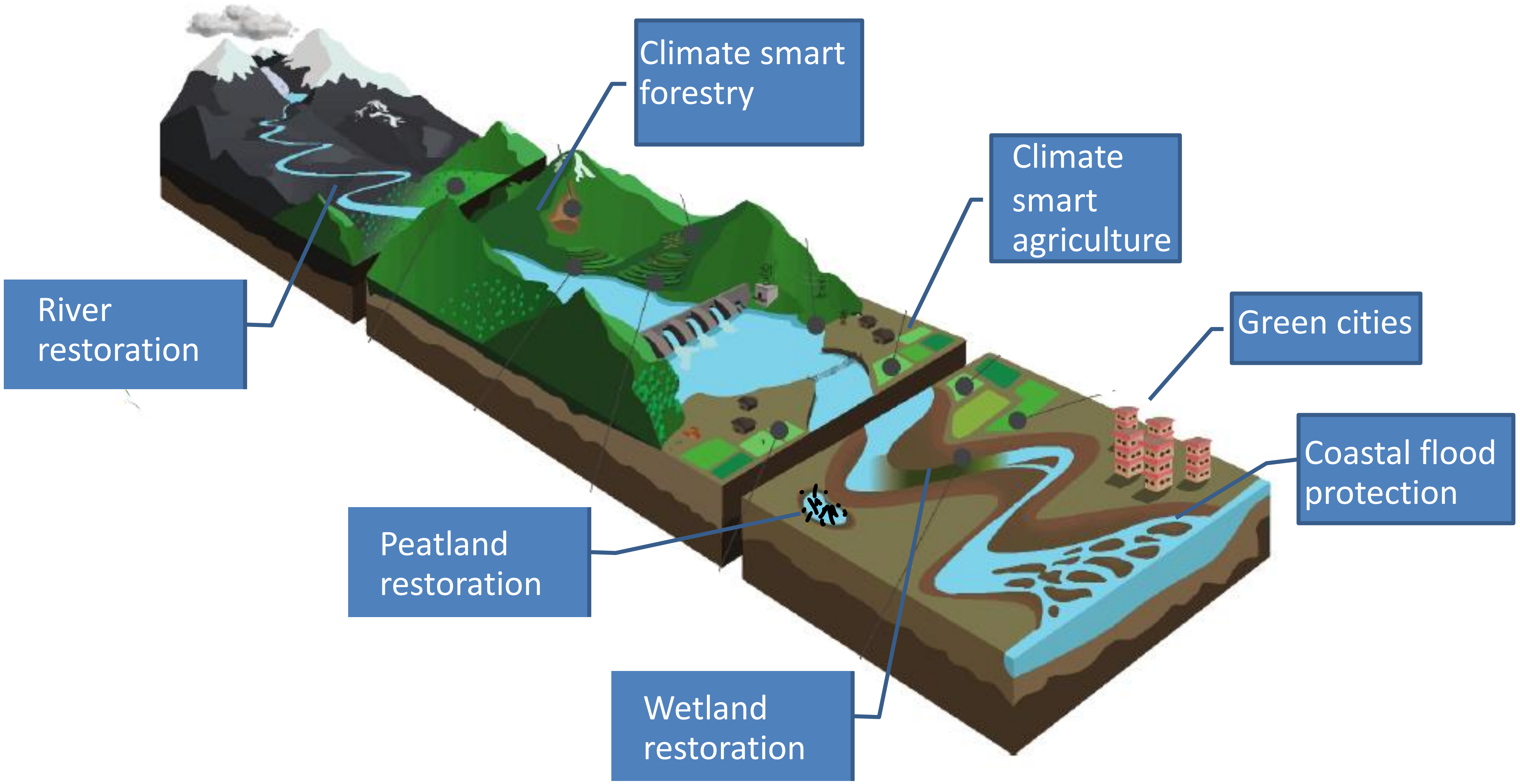
| NbS activity | GRAZING OPTIMIZATION | IMPROVED RICE CULTIVATION | BIOCHAR | CROPLAND NUTRIENT MANAGEMENT | CONSERVATION AGRICULTURE | TREES IN CROPLANDS | IMPROVED PLANTATIONS |
|---|---|---|---|---|---|---|---|
| Benefits | Climate, Biodiversity, Water, Soil | Climate, Water, Soil | Climate, Soil | Climate, Biodiversity, Water, Soil, Air | Climate, Water, Soil, Air | Climate, Biodiversity, Water, Soil, Air | Climate, Biodiversity, Water, Soil, Air |
| Functions | Improve animal grazing intensity, pasture management and feed practices to reduce GHGs. | Adopt water management techniques, improve drainage, practice residue incorporation. | Increase use of biochar to increase carbon storage | Reduce excesive ferrtilizer and other additives and remove perverse incentives to increase fertilizer use. | Cultivate additional cover crops in fallow period; shift to reduced or zero tillage. | Promote integration of trees into agriculture lands to increase habitat value. | Extend harvest rotation lengths on intensively managed production forests. |

CLIMATE BIODIVERSITY WATER SOIL AIR

## In other landscape

| NbS activity | AVOIDED FOREST & GRASSLAND CONVERSION; REFORESTATION | AVOIDED COASTAL WETLAND IMPACTS | NATURAL FOREST MANAGEMENT | WETLAND, PETLAND RESTORATION | FIRE RISK MANAGEMENT |
|---|---|---|---|---|---|
| Benefits | Climate, Biodiversity, Water, Soil, Air | Climate, Biodiversity, Water, Soil | Climate, Biodiversity, Water, Soil | Climate, Biodiversity, Water, Soil, Air | Climate, Biodiversity, Water, Soil, Air |
| Functions | Improved forest managent practices for carbon storage and biodiversity/ land/water conservation | Coastal wetland conservation causes loss of organic carbon and wate quality in mangroves, saltmmarshes and seagrass ecosystes | Extended logging rotations, voluntary certification, improoved tenure or cease logging | Re-wetting and replanting with native wetlands to address water quality and mitigate floods | Prescribed fire or controlled burns to reduce risk of catastrophic fire and errosion and water quality |

# Nature-based climate solutions



# Needed actions for NbS

- Develop diagnostic assessment tools for assessment of key landscape
  - Identify problem (fertility, water etc.)
  - Quantify the problem and severity level
  - Locate (geographic) and identify scale (region, subnational, watershed)
  - Identify the causes of problem, timeframe (since when)
  - Impact on ecosystem (agriculture), and society
- Identify and agree upon landscapes to target for NbS applications, specifically high levels or risk of ecosystem degradation
- Set up multidisciplinary networks for integrated landscape design dialogue platforms
- Implement complimentary NbS approaches via action research, participatory experiments and alike
- Establish regular longitudinal monitoring and reporting systems
- Link NBS work to policy processes, e.g. through B/C analysis, policy consultations, contribution to national reporting (e.g. NDC)
- Identify ways to scale-up NBS though public funds, innovative financing mechanism

# Examples

| Costs of constructing an infiltration area with an urban riparian park | Costs in US$ |
|---|---|
| • Retention tank excavation<br>• Excavation artificial wetland 200 | 21.494,20 |
| • Sedimentation chamber<br>• Excavation and modification of existing well<br>• Trench excavation for 1.2 m gray water pipe<br>• Overflow pipe connection and placement 75 mm diameter 6 m<br>• Mesh placement in the pit to retain trash | 34.533,63 |
| • Adaptation tube for positioning rain sensors<br>• Rainwater attenuation tank | 1.750,00 |
| **Total implementation costs** | 57.777,83 |

Excavation for the infiltration of gray water

Installation of the rainwater attenuation tank

Sedimentation tank and grease trap for gray water – pretreatment

## TBL-CBA of the selected NBS, Costa Rica

[NBS: Infiltration area and urban riparian park]

| Parameter | Description | Total in US$ for 200 families in the first year | Total in US$ for 200 families in the second year |
|---|---|---|---|
| Financial | Real costs | | |
| | Cost of implementing the NBS | 57.777,80 | 6.400,00 |
| | Operations and maintenance costs | 6.400,00 | |
| | Costs related to the observation of the nature-society interaction | 1.600,00 | |
| | Cost for promoting the benefits of NBS and stakeholders' involvement | 9.500,00 | |
| | Cost for the co-design of the NBS | 4.000,00 | |
| | Cost for the knowledge transfer of the RWL | 2.000,00 | |
| Society | Perceived benefits | | |
| | Potential cost savings in recreational activities | 26.800,00 | 26.800,00 |
| | Potential increase of property value | 38.812,00 | 38.812,00 |
| | Potential cost savings related to energy consumption | 14.668,10 | 14.668,10 |
| Environmental | Perceived benefits | | |
| | Potential cost savings related to water sanitation | 2.640,00 | 2.640,00 |
| Total economic cost | | −81.277,80 | −8.400,00 |
| Total society benefit | | 80.280,10 | 80.280,10 |
| Total environmental benefit | | 2.640,00 | 2.640,00 |
| TNPV | | 1.642,30 | 76.520,10 |

Neumann and Hack, 2022
https://doi.org/10.1016/j.eiar.2022.106737

# Long-term effectiveness of NBS under climate change scenarios in Medina del Campo, Spain

- Socio-economic context in which NBS are applied significantly influence the performance of NbS.
- Benefits delivered by NbS may be compromised if a balance between nature, economic growth and society is not found.
- NBS should not be considered as a single action to protect or restore nature but as a process that engages with society to merge natural and human systems into a wholly unique system.

| Climate scenarios / Management-NBS strategies | RCP2.6 | RCP 4.5 | RCP 8.5 |
|---|---|---|---|
| BAU | • Extractions 21.7Hm3/month<br>• No measure implemented<br>• Tested in soils with medium Permeability | | |
| Moderate reductions of GW extractions | • Reduction of 20% of extractions (17.36Hm3/month)<br>• Medium Permeability soils | | |
| NBS strategies implemented | • Soil conservation practices (increase of infiltration 20%)<br>• Vegetation Cover increase<br>• Artificial recharge | | |
| NBS and high level of citizens awareness | • NBS implemented<br>• Measures to increase the level of citizens awareness (i.e. stakeholders engagement) | | |
| NBS+ Extractions reduction | • Soil conservation practices<br>• Vegetation Cover increase<br>• Artificial recharge<br>• Extractions reduction 20% | | |

Martín et al, 2021
https://doi.org/10.1016/j.scitotenv.2021.148515

## Benefits and Co-benefits of the NbS implementation at city level

(average values of the indicator across the city and standard deviation).

Possible effects of scaling up NbS depend as same scenario can give different results in different places

- Existing opportunities to integrate NbS in the urban fabric of the cities, and
- Capacity of each NbS type to deliver benefits in specific conditions.

Cortinovis et al., 2022
https://doi.org/10.1016/j.ufug.2021.127450

| City | Scenario | NBS benefits and co-benefits – average values and standard deviation | | | | |
|---|---|---|---|---|---|---|
| | | Heat mitigation (-) | Runoff reduction (%) | Carbon storage (ton/ha) | Biodiversity potential (-) | Overall greenness (-) |
| Barcelona Spain | *Baseline* | 0.309 (± 0.257) | 50.18 (± 33.71) | 87 (± 107.8) | 0.36 (± 0.33) | 35.48 (± 28.81) |
| | *GreenRoofs* | 0.309 (± 0.257) | 55.67 (± 33.47) | 93 (± 104.6) | 0.55 (± 0.35) | 35.48 (± 28.81) |
| | *ParkingAreas* | 0.309 (± 0.257) | 50.39 (± 33.65) | 87 (± 107.8) | 0.36 (± 0.33) | 35.46 (± 28.81) |
| | *Parks* | 0.319 (± 0.260) | 51.24 (± 34.07) | 91 (± 108.3) | 0.38 (± 0.35) | 36.98 (± 28.54) |
| | *StreetTrees* | 0.314 (± 0.254) | 50.76 (± 33.90) | 90 (± 107.7) | 0.37 (± 0.33) | 36.29 (± 28.54) |
| | *GreenDream* | 0.324 (± 0.257) | 57.49 (± 33.61) | 98 (± 105.9) | 0.59 (± 0.36) | 37.72 (± 28.26) |
| Malmö Sweden | *Baseline* | 0.185 (± 0.131) | 58.34 (± 29.24) | 67 (± 99.9) | 0.60 (± 0.36) | 60.91 (± 27.57) |
| | *GreenRoofs* | 0.186 (± 0.131) | 61.18 (± 28.62) | 70 (± 98.7) | 0.72 (± 0.36) | 60.91 (± 27.57) |
| | *ParkingAreas* | 0.185 (± 0.131) | 58.71 (± 29.06) | 67 (± 99.8) | 0.61 (± 0.36) | 60.88 (± 27.58) |
| | *Parks* | 0.198 (± 0.150) | 59.23 (± 29.34) | 70 (± 104.9) | 0.62 (± 0.38) | 62.11 (± 27.04) |
| | *StreetTrees* | 0.196 (± 0.130) | 59.32 (± 29.34) | 70 (± 103.6) | 0.65 (± 0.35) | 62.26 (± 26.33) |
| | *GreenDream* | 0.210 (± 0.146) | 63.37 (± 28.37) | 77 (± 107.6) | 0.80 (± 0.36) | 63.40 (± 25.84) |
| Utrecht Netherlands | *Baseline* | 0.247 (± 0.144) | 58.53 (± 32.14) | 113 (± 131.2) | 0.63 (± 0.38) | 61.02 (± 23.69) |
| | *GreenRoofs* | 0.249 (± 0.143) | 62.02 (± 31.42) | 116 (± 129.1) | 0.79 (± 0.38) | 61.02 (± 23.69) |
| | *ParkingAreas* | 0.247 (± 0.144) | 58.91 (± 31.95) | 113 (± 131.2) | 0.63 (± 0.38) | 60.88 (± 23.72) |
| | *Parks* | 0.259 (± 0.157) | 59.06 (± 32.20) | 117 (± 134.8) | 0.64 (± 0.39) | 61.74 (± 23.60) |
| | *StreetTrees* | 0.255 (± 0.140) | 59.31 (± 32.22) | 116 (± 133.1) | 0.66 (± 0.37) | 62.10 (± 22.90) |
| | *GreenDream* | 0.269 (± 0.151) | 63.70 (± 31.16) | 124 (± 135.1) | 0.85 (± 0.37) | 62.65 (± 22.82) |

| Scenario | Strategy | Land cover transition rules |
|---|---|---|
| *Baseline* | – | current land cover |
| *GreenRoofs* | installing green roofs | extensive green roofs are installed on all roofs with size above 40 $m^2$ and angle below 20 degrees |
| *ParkingAreas* | de-sealing parking areas | existing parking areas are de-sealed and converted into concrete-reinforced lawns; trees existing on the areas are maintained |
| *Parks* | enhancing vegetation in urban parks | part of the areas currently sealed (excluding paths, sport fields, allotments, and cemeteries) are converted into low vegetation; the tree coverage is increased by adding a tree every 100 $m^2$ of plantable area |
| *StreetTrees* | planting street trees | trees are planted along secondary streets and residential roads, whenever enough space is available (no interference with traffic) |
| *GreenDream* | all of the above | a combination of all of the above |

## Stakeholder perception on NBS in two Portuguese cities

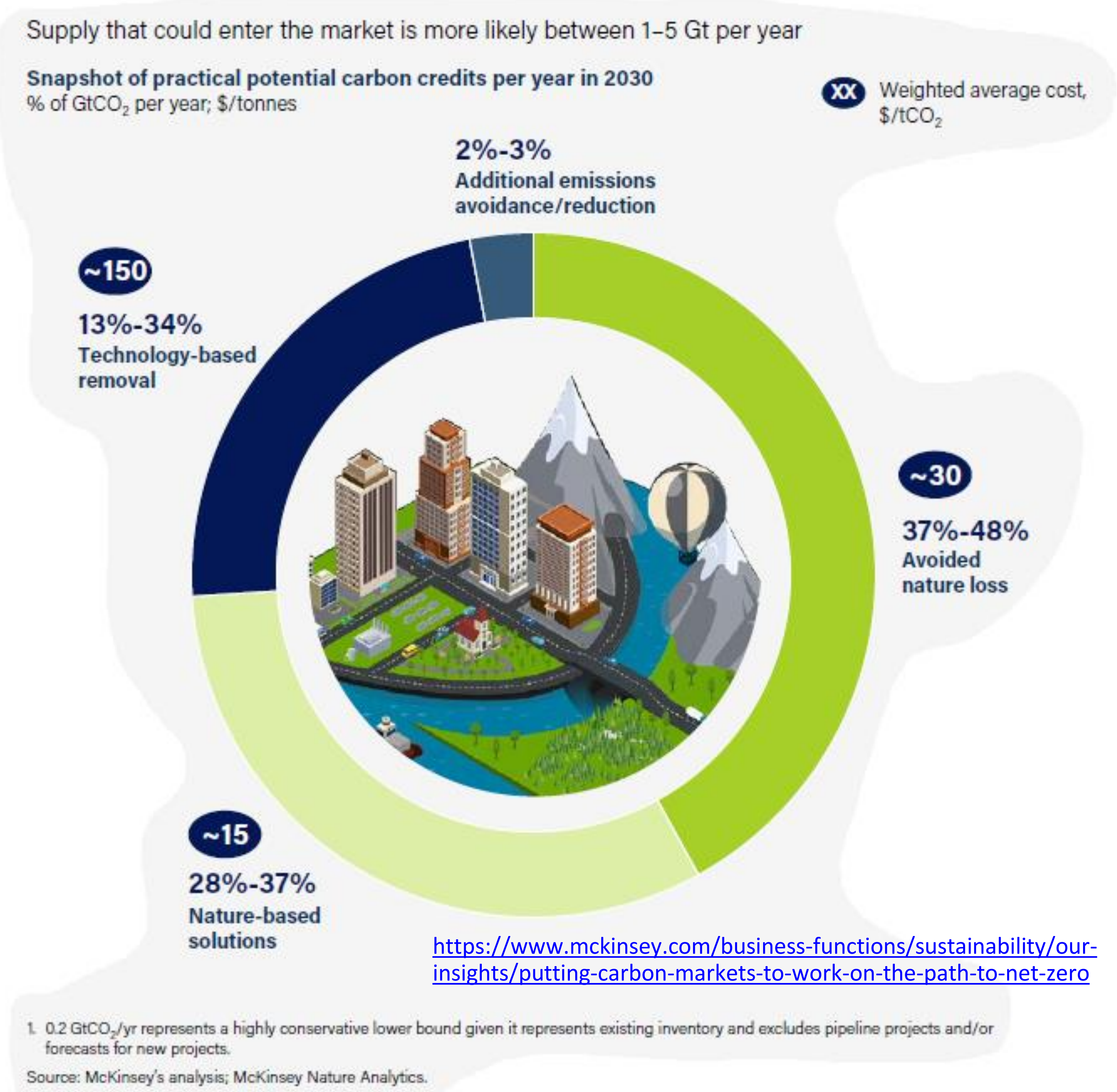
Preferred NbSs were

- planting more urban trees,
- making green shaded areas
- rehabilitating riverbanks.

Ferreira et al., 2021
https://doi.org/10.1016/j.jenvman.2021.113502

NbS can address climate change through
- addressing impacts
- sectoral mitigation and adaptation

NbS / NCs could account for 65–85% of the total supply potential by 2030




https://www.mckinsey.com/business-functions/sustainability/our-insights/putting-carbon-markets-to-work-on-the-path-to-net-zero

Additional references

https://www.nature-basedsolutions.com/
https://www.naturebasedsolutionsinitiative.org/
https://www.youtube.com/watch?v=51H-VyIxSjg

Thank you!