



# **COST-BENEFIT ANALYSIS OF URBAN NATURE-BASED SOLUTIONS: A SYSTEMATIC REVIEW OF APPROACHES, SCALES AND OUTCOMES**

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# WHY WE NEED THE ECONOMIC ASSESSMENT OF NBS?

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- Measure of the human welfare derived from the use or appreciation of NBS
- Quantify and communicate the benefits and costs of NBS to decision makers
  - Comparing different investment alternatives

# ECONOMIC FRAMEWORKS TO SUPPORT DECISION-MAKING

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- There exist a variety of frameworks for generating and structuring economic information to support decision-making on NBS
- The choice of which method use depends on the nature of the decision problem and the availability of information

Cost-Effectiveness

Cost-Benefit Analysis

Multi-Criteria Analysis

# COST-BENEFIT ANALYSIS OF NATURE BASED SOLUTIONS

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- Most commonly used economic assessment method for evaluating and comparing investments, projects and policies
- It provides an indication of how much a project or investment contributes to social welfare by calculating the extent to which the benefits of the project exceed costs

# COST-BENEFIT ANALYSIS MAIN ISSUES

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## GENERAL ISSUES OF COST-BENEFIT ANALYSIS

Discount rate  
Temporal horizon → Impact the CBA outcome

## CBA ISSUES IN THE CONTEXT OF NBS

Difficulties in including the full range of benefits → Lack of a readily observable monetary value

Different distribution of the benefits across space and time → Their value might change according to scales at which the assessment has been conducted

# RESEARCH OBJECTIVE

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## OVERVIEW OF CBA STUDIES ON URBAN NBS

### GENERAL INFORMATION

- Type of NBS analysed
- Purpose of the assessment
- Spatial scale of NBS implementation

### CBA ELEMENTS ANALYSIS

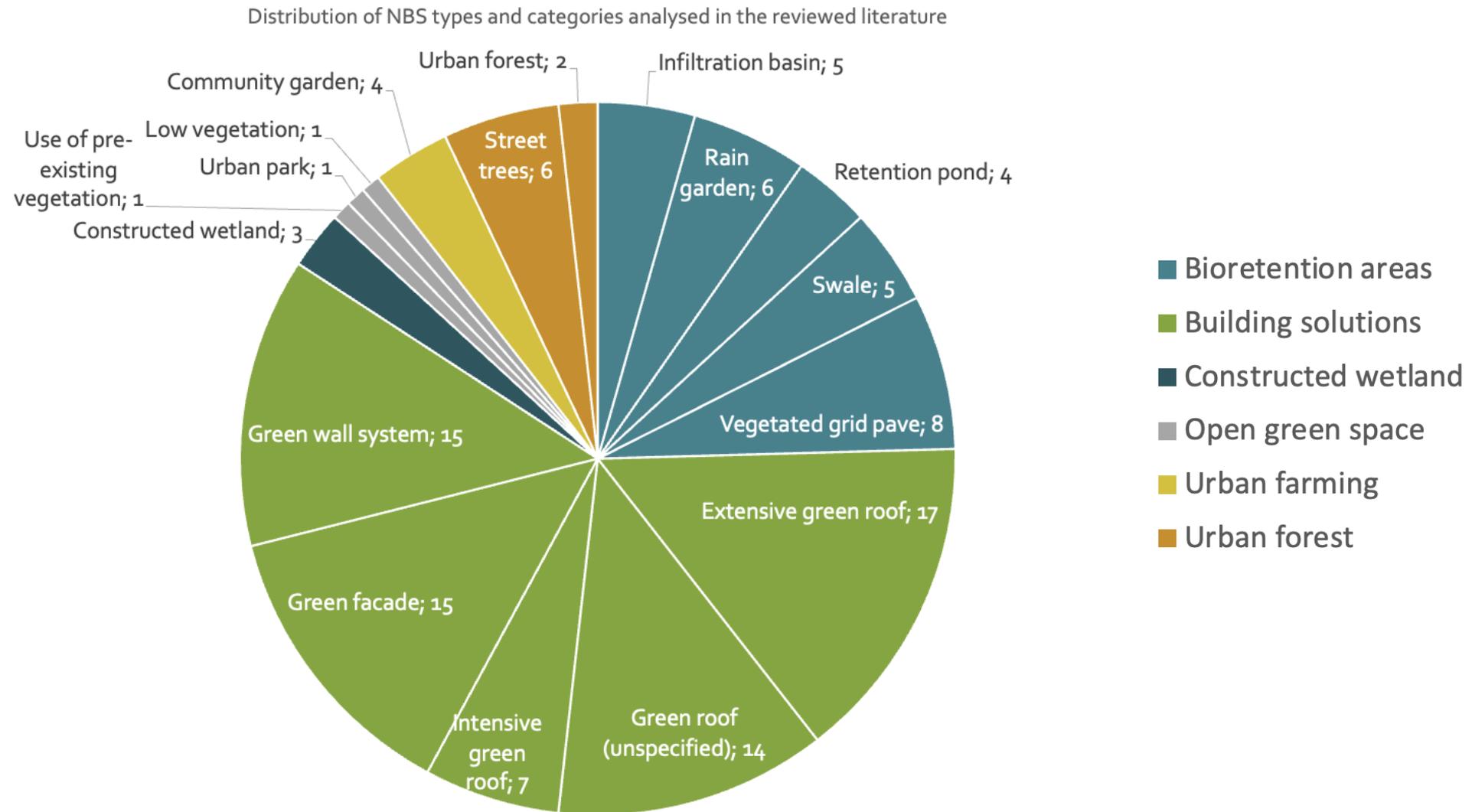
- Discount rate and temporal horizon
- Costs and benefits included
- Outcomes

## BENEFIT ANALYSIS

- Monetary valuation approaches adopted
- Relation between spatial scale of NBS implementation and distribution of the benefits
- Temporal distribution of the benefits

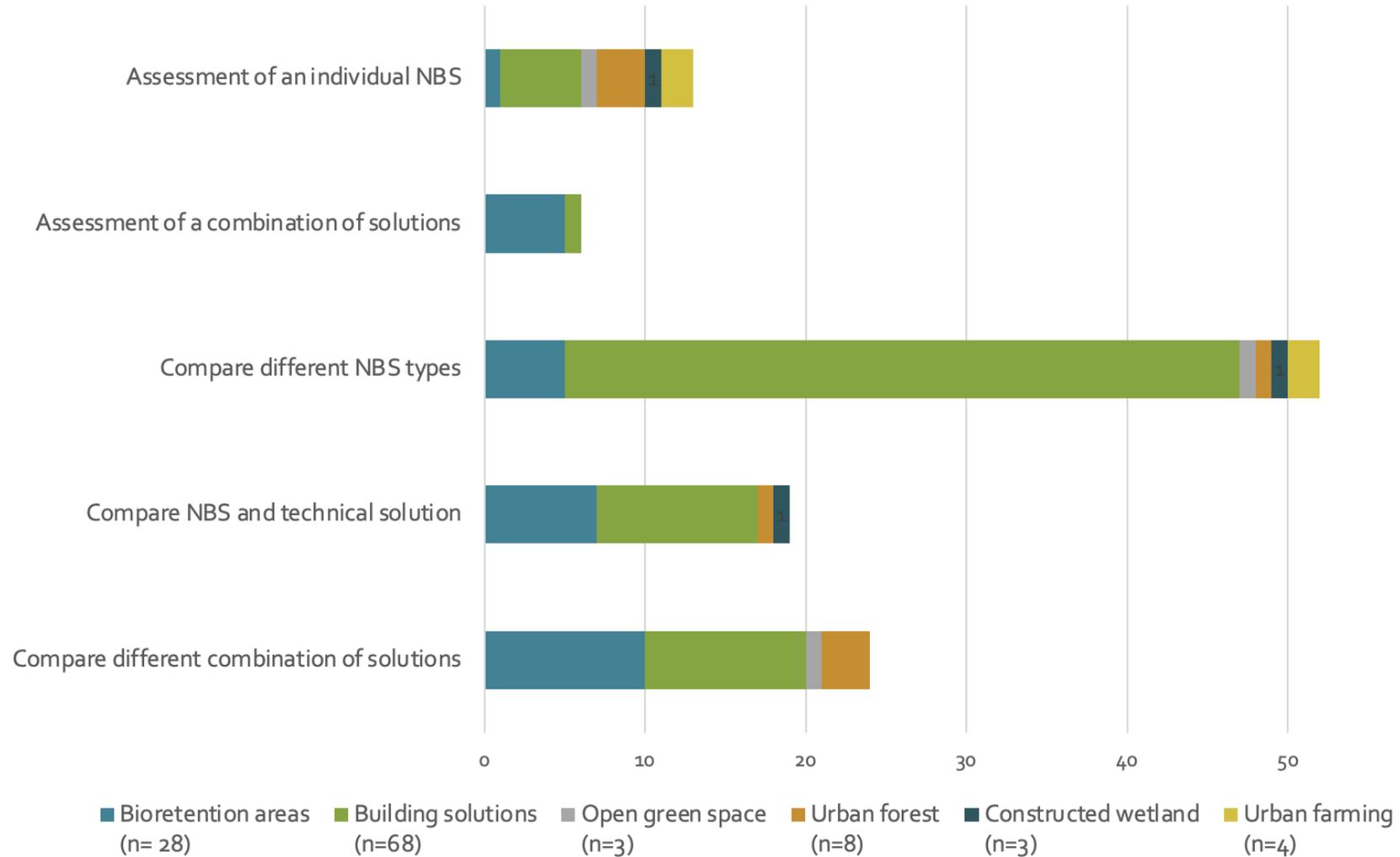
- Review of 48 scientific publication between 2000 and 2022

# NBS TYPES



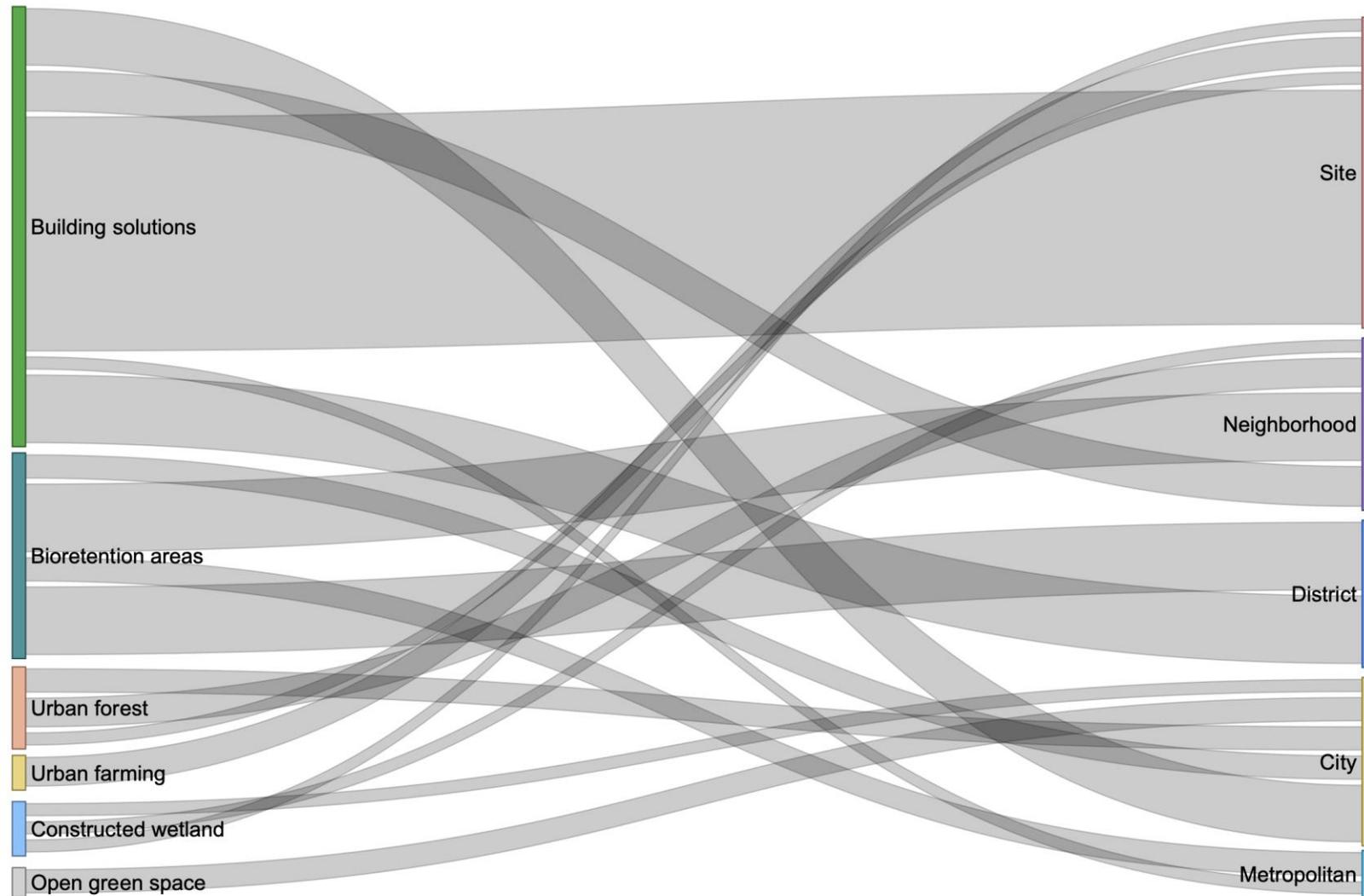
# PURPOSE OF THE ASSESSMENT

Distribution of the purpose of CBA assessment among NBS categories



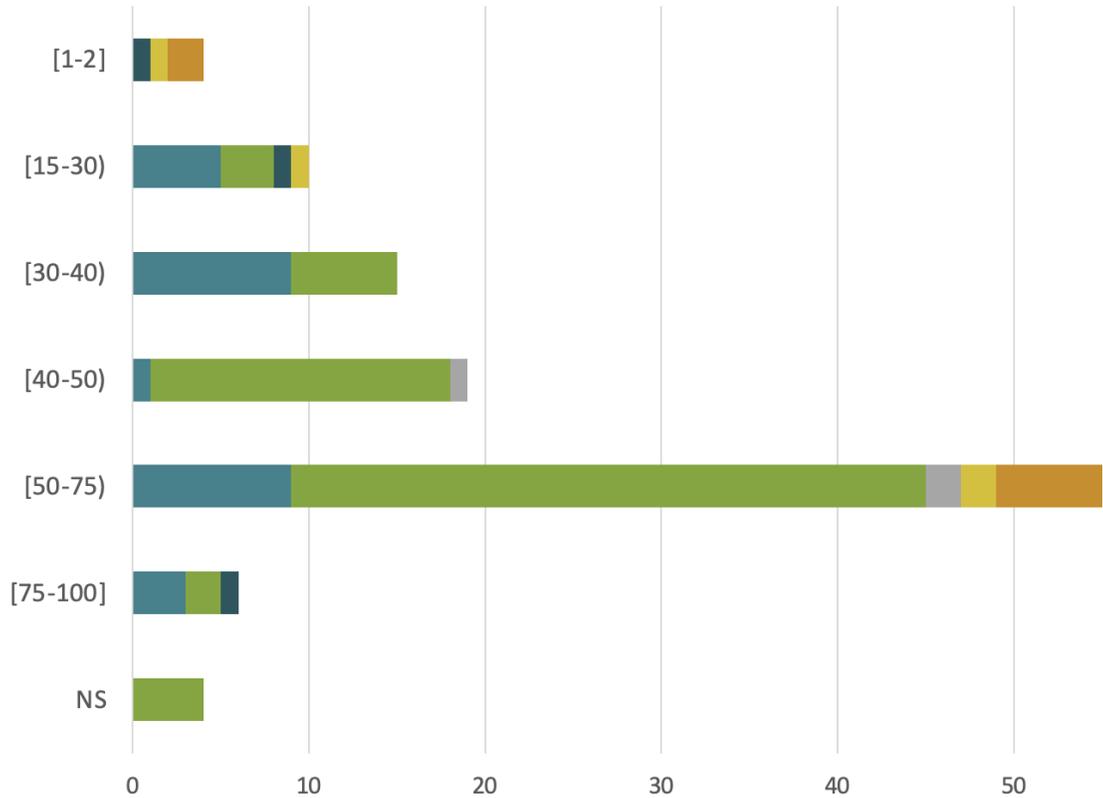
# SPATIAL SCALE OF IMPLEMENTATION

Distribution of the spatial scale of implementation for each NBS category

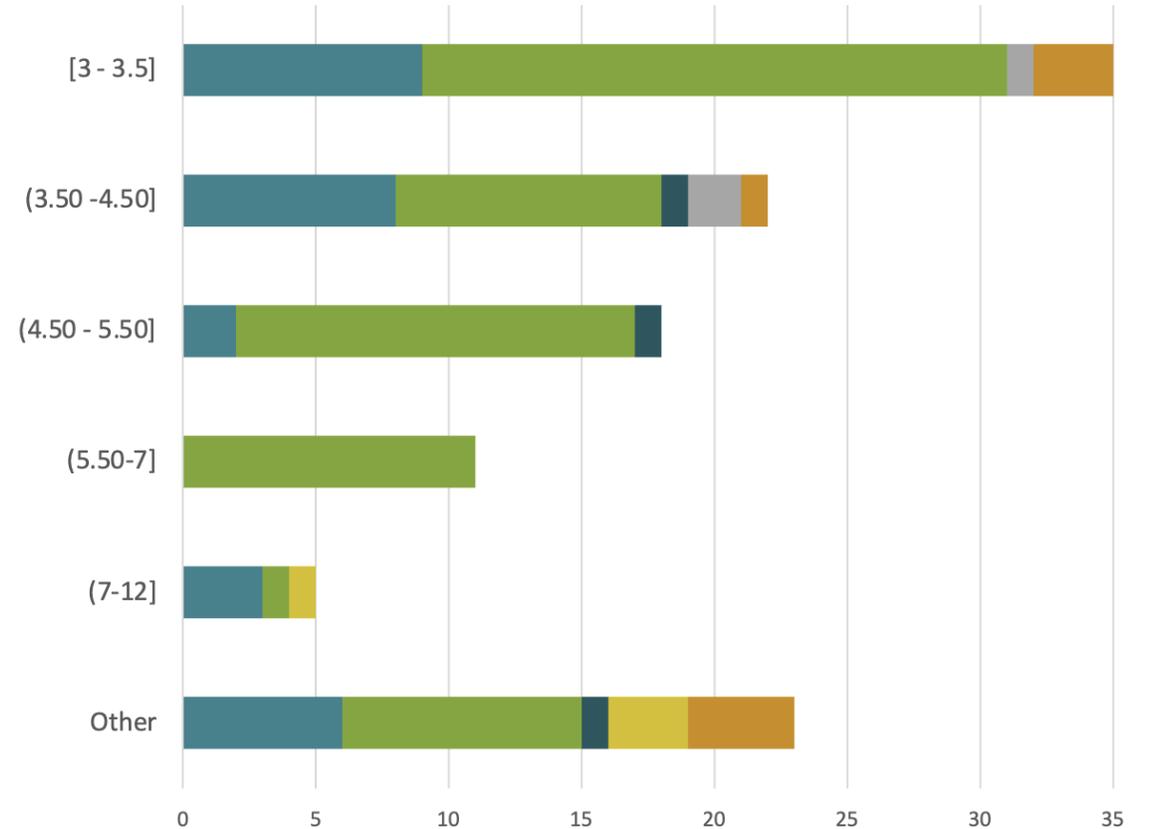


# TEMPORAL HORIZON AND DISCOUNT RATE

Temporal horizon distribution among NBS categories



Discount rate distribution among NBS categories



■ Bioretention areas  
 ■ Building solutions  
 ■ Constructed wetland  
 ■ Open green space  
 ■ Urban farming  
 ■ Urban forest

# COSTS AND BENEFITS INCLUDED

## Building solutions

### *Benefits included by the majority of the studies:*

- Air quality regulation
- Regulation of water flows
- Aesthetic appreciation
- Increase infrastructure longevity
- Thermal insulation
- Noise reduction

### *Other benefit included:*

- Local climate regulation
- Carbon sequestration and storage
- Moderation of extreme events
- Job creation

### *Costs included by the majority of the studies:*

- Installation costs
- Operation and maintenance costs
- Environmental costs
- Removal costs

## Bioretention areas

### *Benefits included by the majority of the studies:*

- Moderation of extreme events
- Regulation of water flows
- Wastewater treatment

### *Other benefit included:*

- Aesthetic appreciation
- Local climate regulation

### *Costs included by the majority of the studies:*

- Installation costs
- Operation and maintenance costs

# COSTS AND BENEFITS INCLUDED

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## Open green spaces

### *Benefits included by the majority of the studies:*

- Regulation of water flows
- Opportunity for recreation

### *Other benefit included:*

- Aesthetic appreciation
- Mental and physical health
- Air quality regulation

### *Costs included by the majority of the studies:*

- Installation costs
- Operation and maintenance costs
- Opportunity costs

## Urban forest

### *Benefits included by the majority of the studies:*

- Air quality regulation
- Carbon sequestration and storage
- Regulation of water flows

### *Other benefit included:*

- Mental and physical health
- Increase property value

### *Costs included by the majority of the studies:*

- Installation costs
- Maintenance and operation costs
- Opportunity costs

# COSTS AND BENEFITS INCLUDED

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## Community garden

### *Benefits included by the majority of the studies:*

- Provision of food
- Air quality regulation

### *Other benefit included:*

- Carbon sequestration and storage
- Regulation of water flow
- Aesthetic appreciation

### *Costs included by the majority of the studies:*

- Installation costs
- Maintenance and operation costs

## Constructed wetland

### *Benefits included by the majority of the studies:*

- Provision of water
- Moderation of extreme events

### *Other benefit included:*

- Carbon sequestration and storage
- Wastewater treatment

### *Costs included by the majority of the studies:*

- Installation costs
- Maintenance and operation costs

# CBA OUTCOMES

<b>NBS types</b>	<b>negative</b>	<b>positive</b>	<b>mixed</b>
Extensive green roof (n=16)	13%	69%	19%
Intensive green roof (n=7)	14%	71%	14%
Green roof (n=11)	36%	64%	0%
Green wall system (n=15)	13%	87%	0%
Green facade (n=15)	7%	87%	7%
Retention pond (n=4)	0%	50%	50%
Infiltration basin (n=3)	0%	100%	0%
Vegetated grid pave (n=6)	17%	67%	17%
Swale (n=4)	0%	0%	100%
Rain garden (n=6)	33%	50%	17%
Low vegetation (n=1)	0%	100%	0%
Street trees (n=6)	0%	83%	17%
Constructed wetland (n=3)	0%	100%	0%
Urban forest (n=2)	0%	100%	0%
Urban park (n=1)	100%	0%	0%
Use of pre-existing vegetation (n=1)	0%	100%	0%
Community garden (n=4)	0%	100%	0%

# MONETARY VALUATION APPROACHES

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Different monetary approaches has been used to estimate the value of the NBS benefits

Provisioning ES	➡	Production linkages (market prices)
Regulating ES	➡	Cost approaches (avoided damage cost, replacement cost)
Habitat ES	➡	Value transfer
Cultural ES	➡	Behavioural linkages (stated and revealed preferences)

Value transfer has been widely used to estimate the value of all the categories of benefits, in particular cultural and habitat ES

# BENEFITS TEMPORAL AND SPATIAL DISTRIBUTION

## Temporal scale

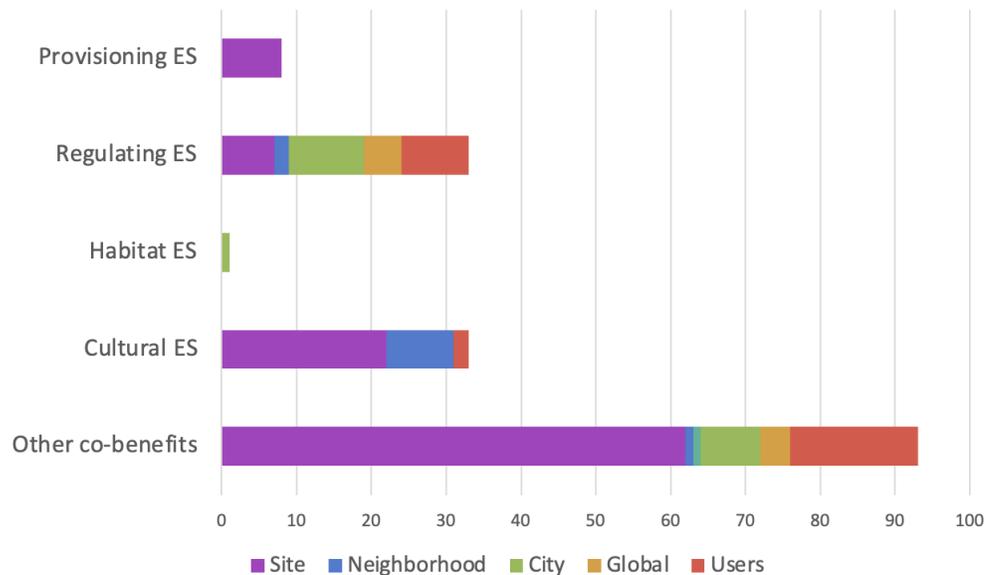
The majority of the paper did not take into account the different temporal distribution of the benefits. In most cases the benefits have been considered every year throughout the entire duration of the analysis.

Few exceptions:

- Provision of food
- Carbon sequestration and storage

## Spatial scale

Benefit spatial distribution of NBS implemented at the site level



The majority of the analysis considered economic benefits that were distributed across a wider spatial scale than the scale of implementation

# EXAMPLE – GREEN ROOF



BENEFIT	MONETARY VALUATION APPROACH	EXAMPLE
Air quality regulation	Avoided damage cost	Avoided costs in terms of health (reduction in hospitalization)
Regulation of water flows	Replacement cost	Reduction in water management costs
Aesthetic appreciation	Behavioural linkages	Estimate the WTP for aesthetic improvement
Increase roof longevity	Avoided cost	Avoided cost of replacing the roof
Thermal insulation	Avoided cost	Avoided cost of energy

# EXAMPLE – RAIN GARDEN



BENEFIT	MONETARY VALUATION APPROACH	EXAMPLE
Wastewater treatment	Replacement cost	Reduction in water management costs
Regulation of water flows	Replacement cost	Reduction in water management costs
Moderation of extreme events	Avoided damage cost	Reduction in costs associated with flood damages
Aesthetic appreciation	Behavioural linkages/Value transfer	Estimate the WTP for aesthetic improvement

# CONCLUSION

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- Variations in the benefits considered in the CBA for the same type of NBS
- Variability in the distribution of time horizons and adopted discount rates
- Overall, CBA of NBS have demonstrated economic efficiency
- NBS offer economic advantages on a larger scale compared to their scale of implementation
- Need to consider the different temporal distribution of the benefits

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THANK YOU FOR YOUR ATTENTION