On the Cost-effectiveness of Nature-based Solutions for Reducing Disaster Risk

Marta Vicarelli (1): mvicarelli@econs.umass.edu

Co-authors: Karen Sudmeier-Rieux (4), Ali Alsadadi (3), Michael Kang (3), Madeline Leue (3), Aryen Shrestha (4), Simon Schütze (5), Ella Steciuk (4), David Wasielewski (3), Jaroslav Mysiak (6), Michael Marr (3), Shannon McAndrew (3), and Miranda Vance(3)

1. Department of Economics and School of Public Policy, University of Massachusetts, Amherst, United States of America
2. Universität zu Köln, Germany
3. School of Public Policy, University of Massachusetts, Amherst, United States of America
4. Amherst College, Amherst, United States of America
5. United Nations University and University of Bonn, Germany
6. Centro Euro-Mediterraneo sui Cambiamenti Climatici | Università Ca' Foscari, Venezia, Italy

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Economics

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Climate Extremes & Risk: impacts, nature-based disaster risk reduction and climate adaptation
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Research question

Assessing existing scientific knowledge on the cost-effectiveness and equity of Nature-based Solutions

Special focus on:

- Ecosystem-based Disaster Risk Reduction (Eco-DRR) programs
- Ecosystem-based Climate Adaptation (EbA)
- Ecosystem-based Climate Mitigation (EbM)

Motivation

- Ecosystems and ecosystem services are key to helping achieve
  - Reduction in disaster risk
  - Sustainable development
  - Climate change mitigation and adaptation
- Their role is now recognized by major international framework agreements
  - Convention on Biological Diversity, 2022
  - Sharm el-Sheikh Implementation Plan (UNFCCC-COP27), 2022
  - Sendai Framework for Disaster Risk Reduction 2015-2030

There is very limited knowledge about the overall economic performance of NbS

- Cost-effectiveness
- Equity and distributional considerations

Database of Peer Reviewed Literature: Inclusion Criteria

- The study performs an economic assessment of the net benefits of an intervention (i.e., ecosystem service or ecosystem function or an ecosystem-based intervention).

- The economic assessment takes into account the protective services provided by the intervention in reducing hazard risk (i.e., reduced exposure or vulnerability).

- The study compares the outcomes of an intervention with no intervention or other type of intervention.

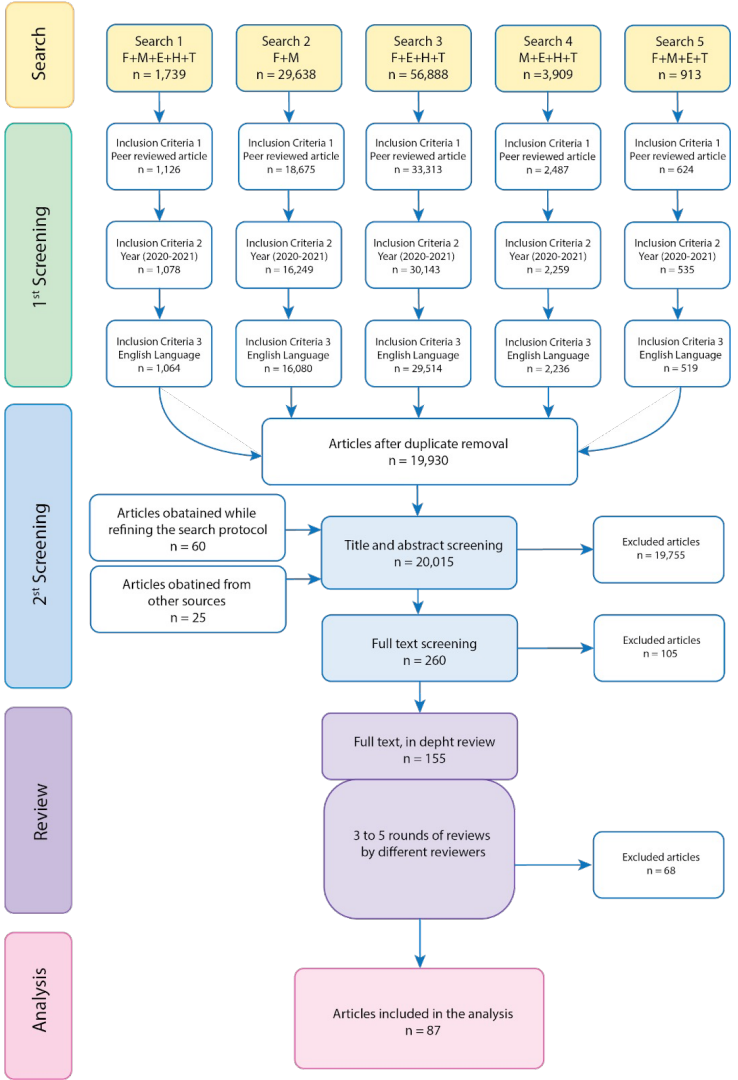
* English-language peer-reviewed articles

Search and review protocol

- **Global database** of **peer-reviewed studies** (2000-2021) on economic valuation of Nature based Solutions (NbS)
  - More than 20,000 screened
  - 155 articles reviewed in depth
  - 87 retained in the database

- **Global review**

We hope to provide key information for practitioners to maximize effectiveness of project implementation



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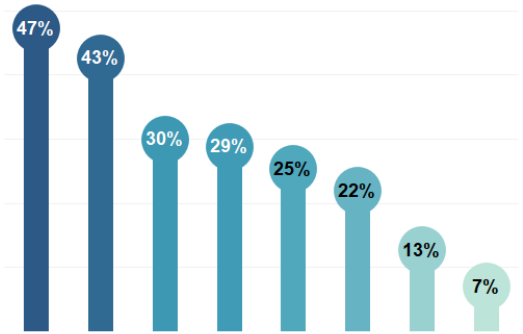
Key Findings

a)



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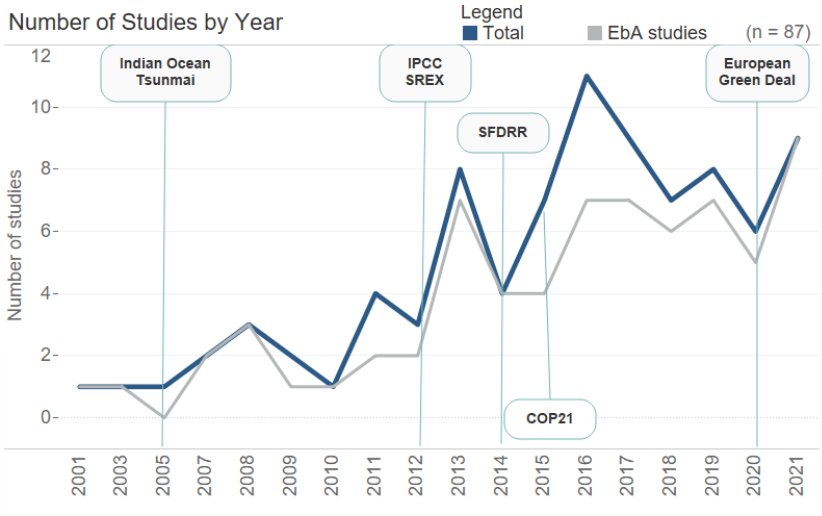


	Total	Coastal	Wetland	Forest	Mangrove	Urban	Riparian	Agro-ecosystem	Coral Reef		2001	2003	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total	**87**	**41**	**37**	**26**	**25**	**22**	**19**	**11**	**6**		**1**	**1**	**1**	**2**	**3**	**2**	**1**	**4**	**3**	**8**	**4**	**7**	**11**	**9**	**7**	**8**	**6**	**9**
Floods	**72**	40	37	12	25	20	18	9	6		1	1	1	2	2	1	1	3	2	7	4	5	10	7	7	5	6	7
Storms	**57**	37	28	7	24	17	10	4	6		1	1	1	1	2	1	1	2	2	8	3	3	7	6	4	3	5	6
Erosion	**29**	18	16	9	9	1	4	7	3		1	1		1	1		1	3	1	3	2	4	5	1	1	1		3
Pollution/excess carbon	**17**	4	10	8	3	6	7	6	1			1		1	1		1	1	2	3	1		3	2				1
Landslides	**10**	1	1	10	1	1	1	1	1						1				1			3		1	1	2		1
Avalanches	**9**			9				1							1	1		1	1			3		1				1
Droughts	**5**	1	1	2		2		2															1	1		1		2
Forest Fires	**5**	1	1	4				2				1								1				2				1
Heatwaves	**5**	1	1	1		4		1				1												3				1
Tsunamis	**4**	4	4	1	4	1	1		2					1	1								1		1			
Earthquakes	**3**	1	2	1	1	3	2		1														1		1		1	

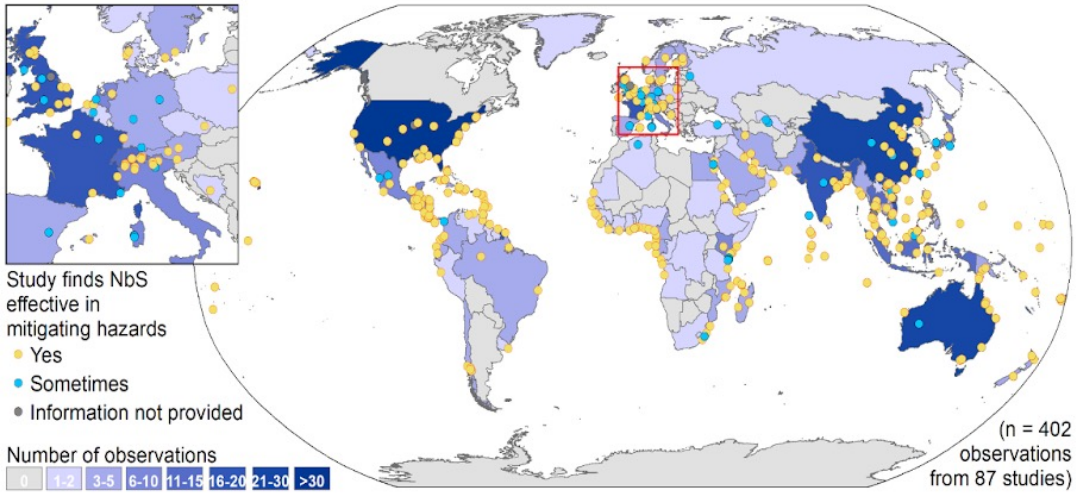
Distribution of the studies reviewed (n=87) across the ecosystems and hazards they analyzed

Geographic Distribution

Property rights structure

Financing

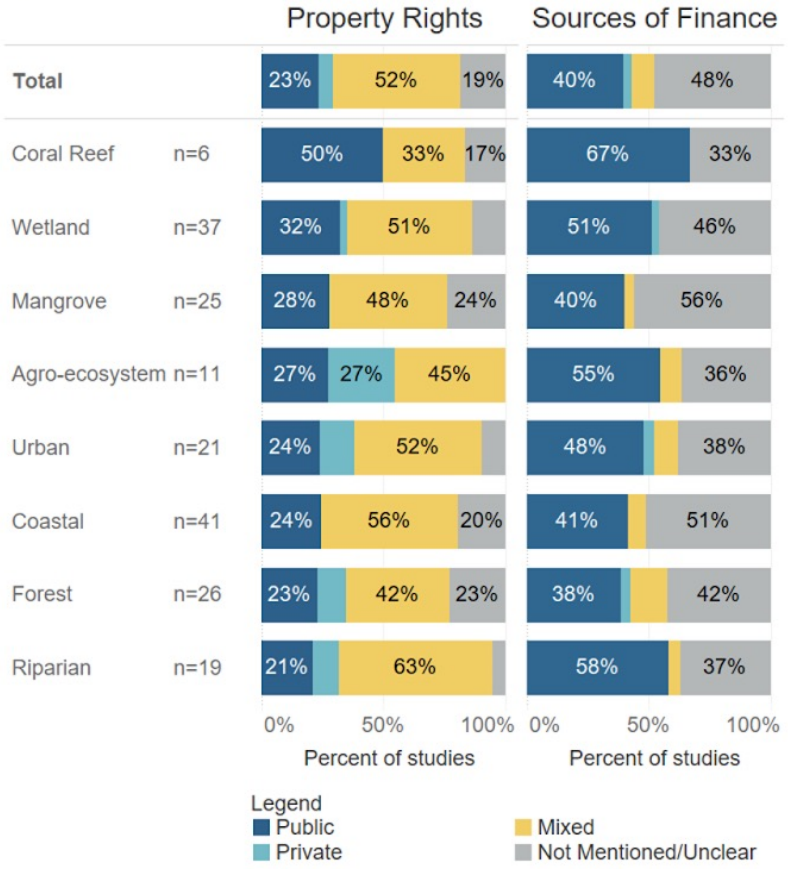
a)



b)

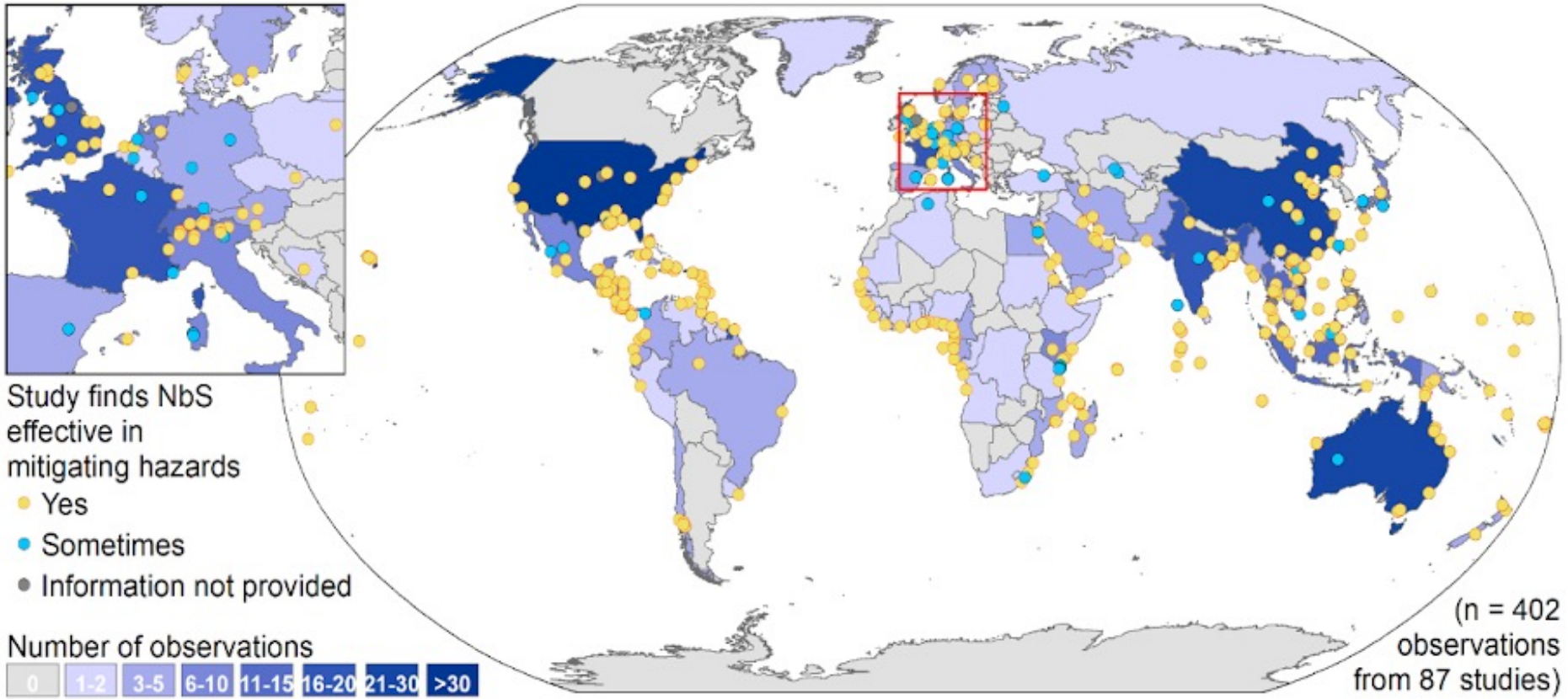
	Africa n=12	Asia n=30	Central America n=12	Europe n=36	Middle East n=3	North America n=24	Oceania n=10	South America n=6
Agro-ecosystem		7%	8%	17%		4%	10%	
Coastal	75%	67%	75%	22%	100%	79%	50%	83%
Riparian	25%	7%		33%	33%	8%	30%	17%
Urban	25%	27%	8%	25%	33%	17%	50%	33%
Mangrove	50%	60%	50%	6%	33%	42%	30%	67%
Forest	8%	10%	17%	53%		8%	10%	
Wetland	8%	37%	25%	39%		58%	30%	17%
Coral Reef		10%	17%	3%		13%	10%	17%

c)



Geographic distribution of the Nature-based Solution (NbS) studies reviewed, cost-effectiveness, property rights and financing

a)

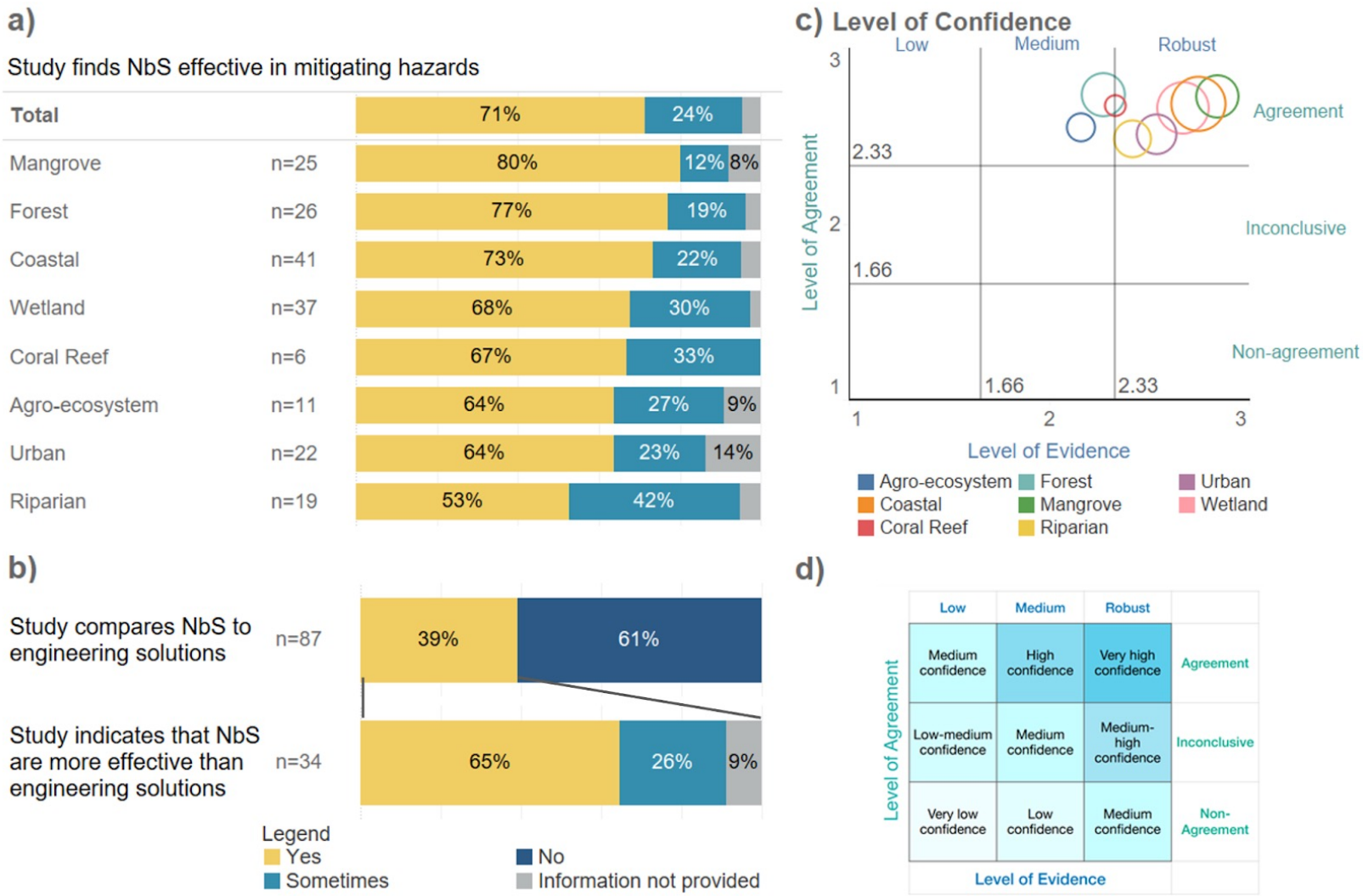

Study finds NbS effective in mitigating hazards
Yes
Sometimes
Information not provided
Number of observations
0
1-2
3-5
6-10
11-15
16-20
21-30
>30
(n = 402 observations from 87 studies)

Cost-Effectiveness

- 71% of studies indicated that NbS have consistently proven to be a cost-effective approach to mitigating hazards

- 24% of studies found NbS cost-effective under certain conditions

Cost-effectiveness and Level of Confidence


a)
Study finds NbS effective in mitigating hazards
Total
71%
24%
Mangrove n=25
80%
12%
8%
Forest n=26
77%
19%
Coastal n=41
73%
22%
Wetland n=37
68%
30%
Coral Reef n=6
67%
33%
Agro-ecosystem n=11
64%
27%
9%
Urban n=22
64%
23%
14%
Riparian n=19
53%
42%
b)
Study compares NbS to engineering solutions n=87
39%
61%
Study indicates that NbS are more effective than engineering solutions n=34
65%
26%
9%
Legend
Yes
Sometimes
No
Information not provided
c) Level of Confidence
Low
Medium
Robust
Agreement
Inconclusive
Non-agreement
Level of Agreement
Level of Evidence
2.33
1.66
1.66
2.33
1
2
3
Agro-ecosystem
Coastal
Coral Reef
Forest
Mangrove
Riparian
Urban
Wetland
d)
Low
Medium
Robust
Medium confidence
High confidence
Very high confidence
Agreement
Low-medium confidence
Medium confidence
Medium-high confidence
Inconclusive
Very low confidence
Low confidence
Medium confidence
Non-Agreement
Level of Agreement
Level of Evidence

Comparison with Engineering Based Solutions

- 34 out of 87 studies compare NbS and engineering-based solutions

Of those 34:

- 65% find NbS solutions more cost-effective than engineering-based solutions
- 91% find NbS solutions more cost-effective than engineering-based solutions at least sometimes.

Type of analyses performed

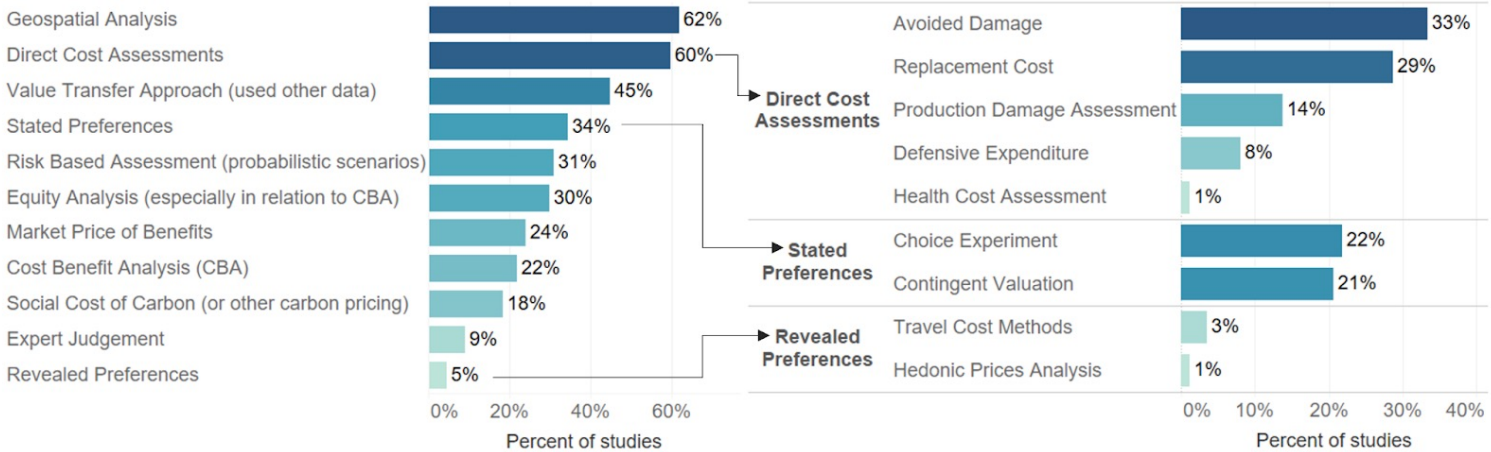
a) Type of Analysis

	Total	Empirical analysis	Empircal analysis with new primary data	Modelling and simulations	Review or metanalysis
Total	**87**	**77**	**64**	**44**	**21**
Coastal	**41**	36	29	24	13
Wetland	**37**	34	25	22	10
Forest	**26**	23	17	13	5
Mangrove	**25**	22	15	19	8
Urban	**22**	17	17	8	4
Riparian	**19**	17	15	8	3
Agro-ecosystem	**11**	11	10	4	2
Coral Reef	**6**	4	1	4	3

b) Equity Analyses

	Income inequalities	Gender	Race and ethnicity	Participation of indigenous groups and local communities	Contribution to SDGs
Total	**30%**	**20%**	**8%**	**30%**	**10%**
Coastal	27%	20%	7%	29%	10%
Wetland	24%	22%	5%	24%	11%
Forest	27%	8%	4%	27%	12%
Mangrove	32%	12%	0%	36%	16%
Urban	45%	36%	14%	41%	18%
Riparian	47%	26%	5%	53%	5%
Agro-ecosystem	55%	9%	9%	36%	18%
Coral Reef	0%	0%	0%	0%	17%

c) Methodologies Used in Economic Evaluations



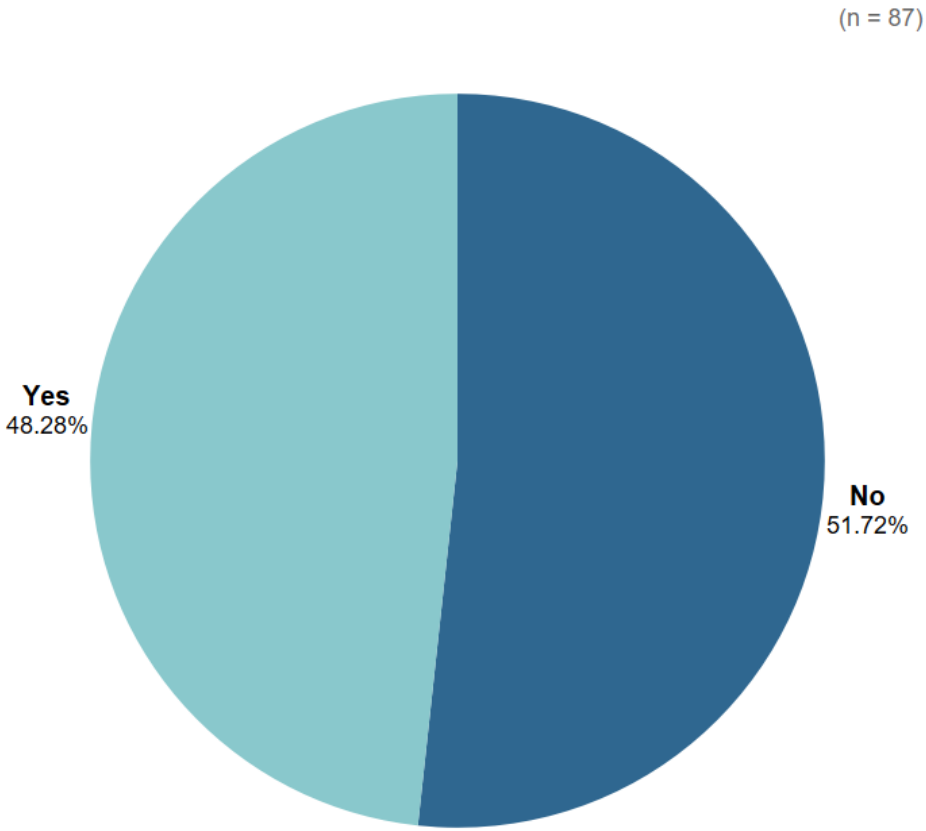
Biodiversity

NbS

- actions to protect, sustainably manage and restore natural or modified ecosystems
- address societal challenges effectively and adaptively,
- simultaneously providing human well-being and biodiversity benefits.

(IUCN, 2016)

Studies reporting that the NbS analyzed contributed to biodiversity benefits



Conclusions

The **results of our meta-analysis** contribute to our understanding of:

- Performance of NbS in terms of cost-effectiveness
- Extent of research on equity and distributional implications
- Economic valuation techniques and approaches used to assess **cost-effectiveness** of NbS
    - Advantages and limitations of different economic evaluation approaches

We hope this study will inform the upscaling of NbS to address the biodiversity-climate crisis

Thank you!

Marta Vicarelli: mvicarelli@econs.umass.edu

Cheonggyecheon (청계천) stream, Seoul, South Korea. Credit: stari4ek/ Wikimedia Commons

Definitions

NbS - Nature-based Solutions

- EbA - Ecosystem-based Climate Adaptation
- EbM - Ecosystem-based Climate Mitigation
- Eco-DRR - Ecosystem-based Disaster Risk Reduction

Credit: World Bank