# Modeling place-based nature-based solutions to promote urban carbon neutrality

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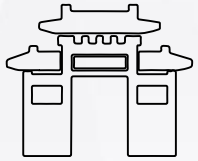

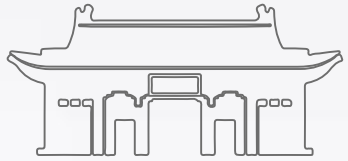

# The role of NbS in Carbon Neutrality

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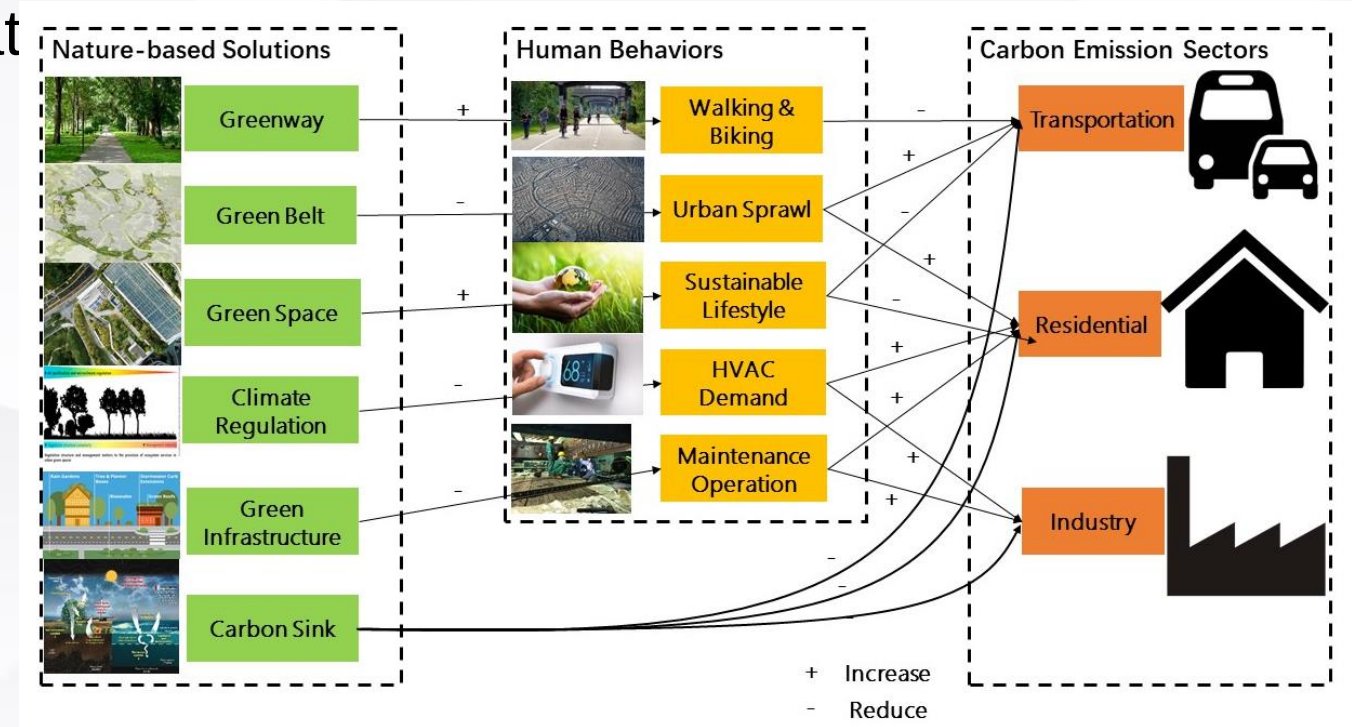
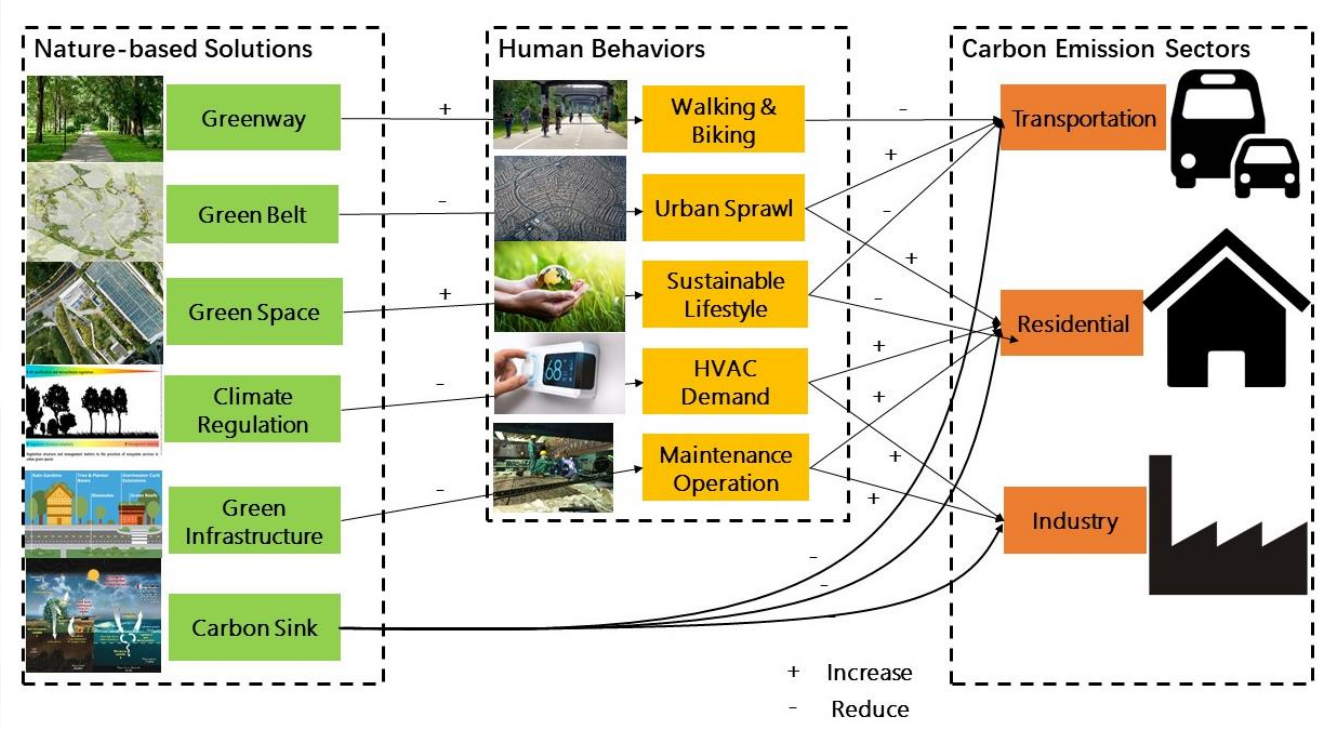


# Research Questions

- 1) Which NbS strategies are effective in addressing urban climate change?
- 2) Where should NbS be deployed to maximize their carbon emissions saving potential?
- 3) What are the co-benefits of NbS measures with regard to different carbon emissions sectors within a location?
- Case Study: Stockholm County, Sweden



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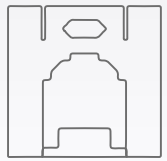
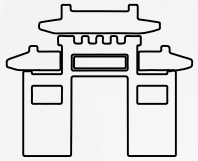
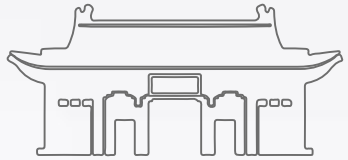






# Method

- Which NbS strategies are effective in addressing urban climate change?
- What are the co-benefits of NbS measures with regard to different carbon emissions sectors within a location?
- Method: Meta-analysis of effects of NbS interventions on carbon emissions mitigation

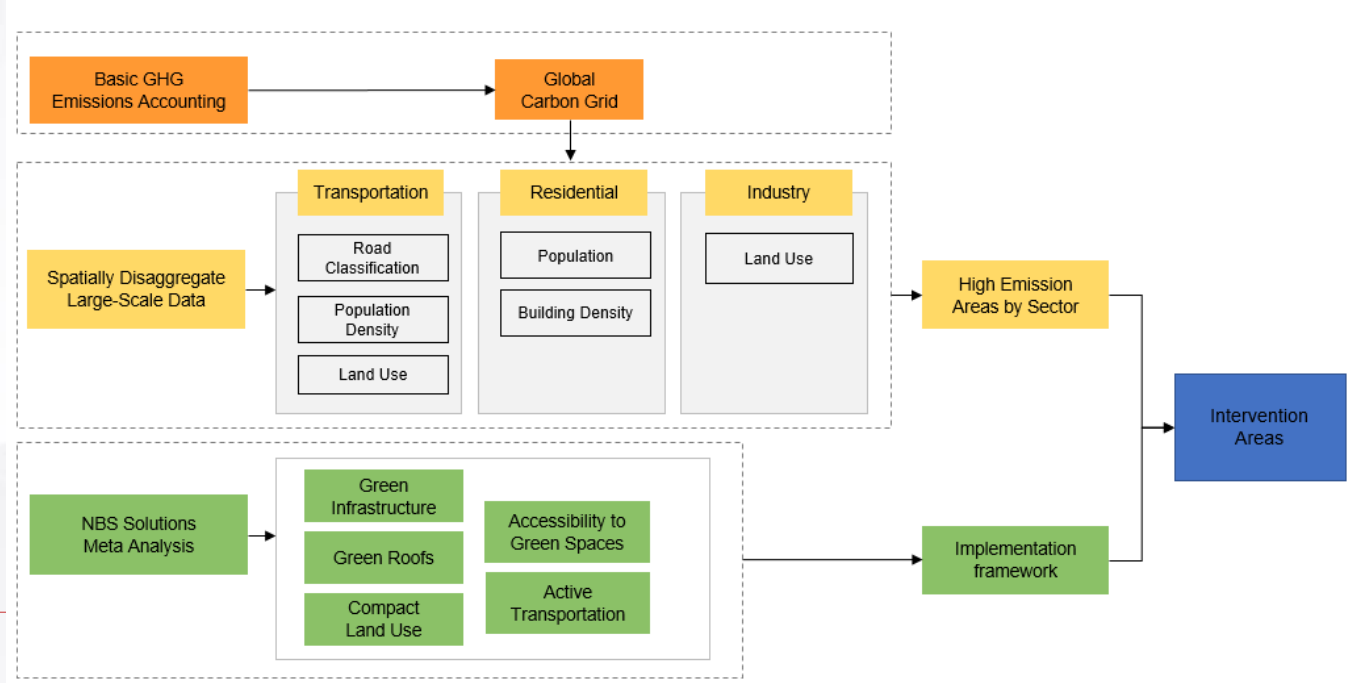



**Table 1.** Basic characteristics of the articles (n=18) included in the review

| Study | Country | Samples | Method | Study period |
|---|---|---|---|---|
| Wang et al., 2015 | China | Five major cities | Panel regression | 1995-2011 |
| Sota et al., 2019 | Spain | Lugo | Sequestration accounting | 40-yar horizon |
| Chen, 2015 | China | 35 major cities | Carbon sequestration | 2010 |
| Anderson & Gough, 2020 | Canada | Ontario | Field study | 2017 |
| Russo et al., 2015 | Italy | Bolzano | Sequestration accounting | 2011 |
| Zhao et al. (2010) | China | Hangzhou | Sequestration accounting | 2000-2002 |
| Yang et al., 2008 | USA | Chicago IL | Mathematical model | 2007 |
| Jahanfar et al., 2018 | Canada | Toronto | Mathematical model | N/A |
| Sarkar et al., 2015 | UK | Greater London | Logistic regression model | 2005-2010 |
| Maizlish et al., 2012 | USA | San Francisco | Mathematical model | 2010 |
| Lindsay et al., 2010 | New Zealand | Nationwide | Historical data analysis | 2003–2006 |
| Qu et al., 2013 | China | Four major cities | Panel regression | 1990-2010 |
| Fang et al., 2015 | China | 30 provincial capitals | Regression model | 1990-2010 |
| Lee & Lee, 2014 | USA | 125 largest cities | Multilevel SEM | 2001 |
| Xu et al., 2019 | EU | 28 EU member states | Panel regression | 2000-2012 |
| Liu & Sweeney, 2012 | Ireland | Great Dublin Region | Model simulation | 2006 |
| Koohsari et al., 2012 | Australia | Melbourne | Survey+logistic regression | 2011 |
| Ye et al., 2015 | China | Xiamen | Correlation analysis | 2009 |

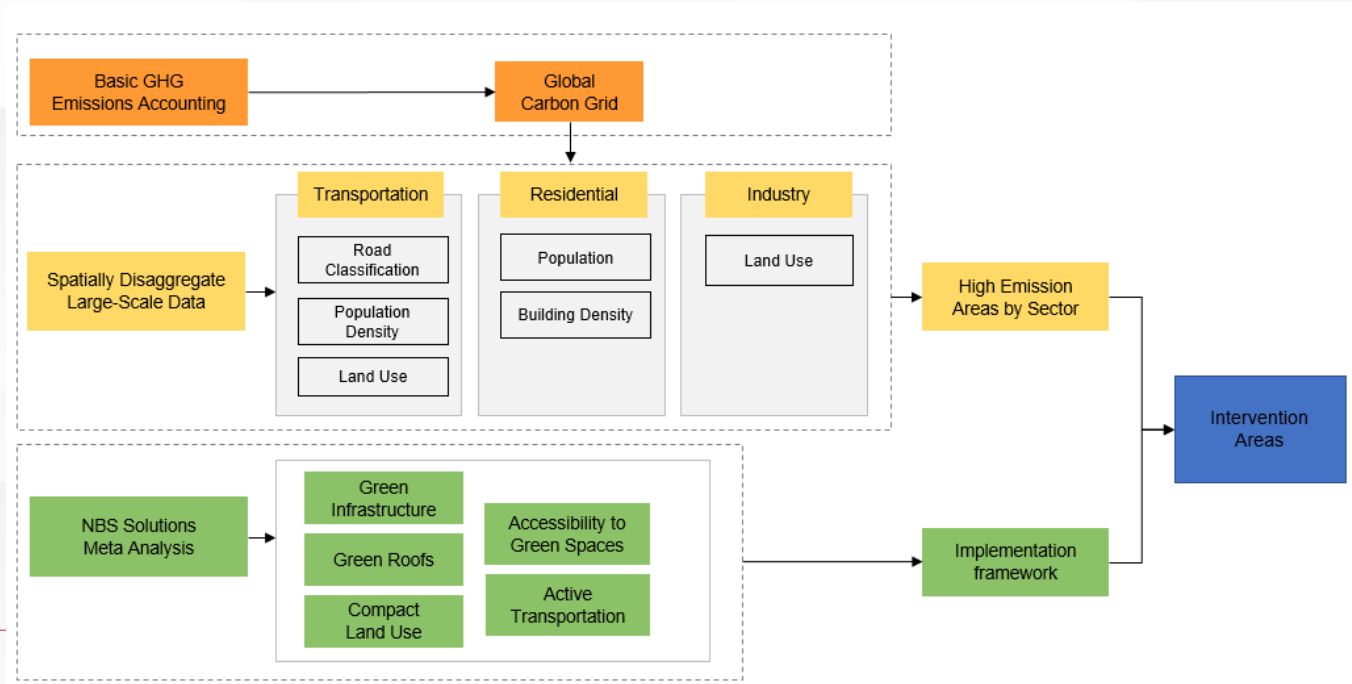
# Method

- 2) Where should NbS be deployed to maximize their carbon emissions saving potential?

- Method:

- High-resolution mapping of carbon emissions for each land use cells, including residential emissions, transportation emissions, industrial emissions;

- Identify priority areas and NbS intervention types.



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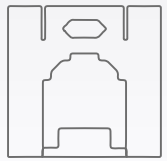
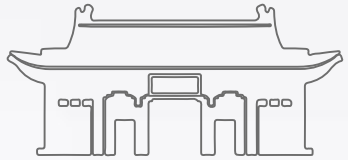




# 4.2 NbS emissions reduction meta-analysis

- Five NbS strategies are rated for different urban settings, characterized by road density, population density, residential density. The columns in the table represent potential NbS strategies and the ratings (1-5) represent the implementation need from lowest to highest priority.

Table 3. Nature-based solution (NbS) strategies for different spatial settings and their carbon emission mitigation effects on different sectors. Ratings (1-5) represent the implementation priority (1for the lowest and 5 for the highest)

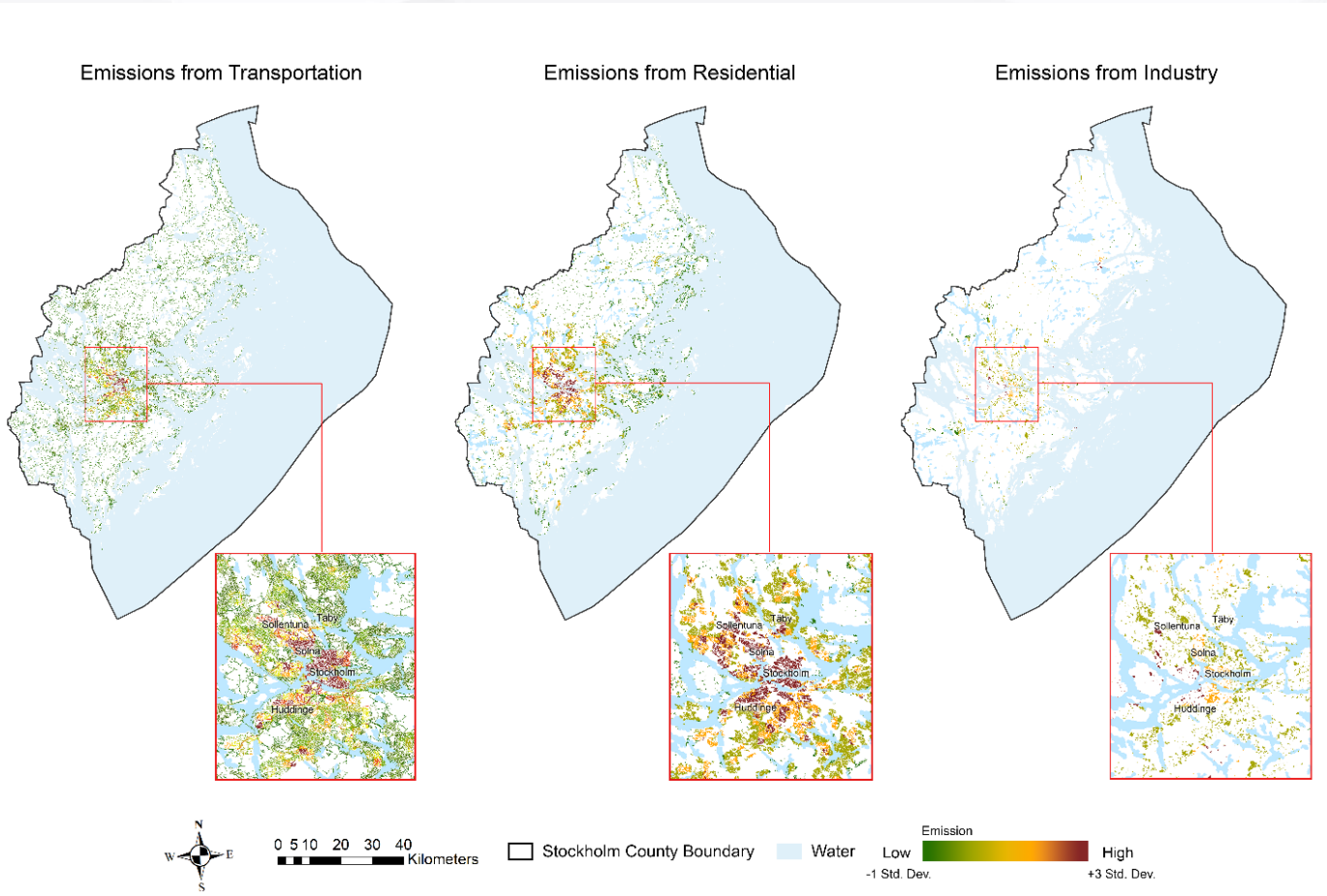
| | Typical areas | Green/blue infrastructure | Green roofs | Street-scape | Green access | Green belt |
|---|---|---|---|---|---|---|
| Transportation emissions reduction | | | | | | |
| High road density & high population density | Urban center and sub-centers | 2 | 3 | 5 | 4 | 1 |
| Low road density & high traffic speed | Rural/peripheral areas | 5 | 1 | 2 | 3 | 4 |
| Low road density & low residential density | Emerging suburbs | 3 | 1 | 2 | 4 | 5 |
| Residential emissions reduction | | | | | | |
| High road density & high population density | Urban center and sub-centers | 4 | 3 | 2 | 5 | 1 |
| Low residential density | Emerging suburbs | 3 | 2 | 1 | 4 | 5 |
| Industry emissions reduction | | | | | | |
| High population density | Urban center and sub-centers | 3 | 5 | 1 | 4 | 2 |
| Low population density | Rural/peripheral areas | 2 | 5 | 1 | 4 | 3 |

# High-emissions areas by sector

- Residential emissions: Highly populated areas, either within the urban center or scattered in peripheral areas, have higher emissions.

- Transportation emissions: Most of the high-emissions areas are in the existing urban center of Stockholm city and in Solna, due in part to high road density and more human mobility and activities.

- Industrial and commercial emissions: less obvious patterns associated with urban development, but related more to where the major energy consumers are located.



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# Priority areas and types of NbS interventions

- Streetscaping, including road greening and improved built environment design and esthetics, emerges as the leading opportunity for densely developed urban centers;

- Green/blue infrastructure preservation appears to be the most widely applicable approach throughout suburban and rural areas of Stockholm County, due to its forested environment and vegetation sequestration potential.

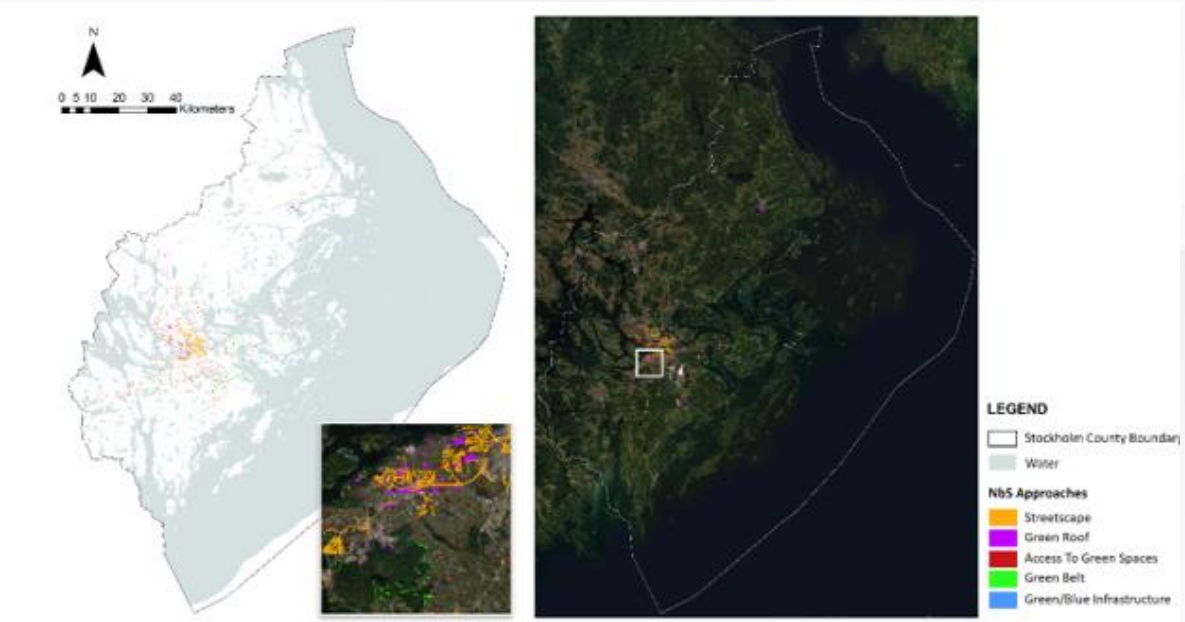


Figure 5. Areas in Stockholm County prioritized for different nature-based solution (NbS) interventions according to our approach, visualized without (left) and with (insert, right) a satellite imagery background, and (right) a zoomed-in image of the Hökmossen area in suburban Stockholm.

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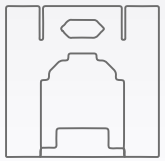

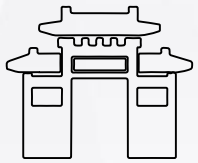

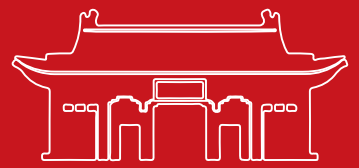

# Takeaways

- While NbS can be deployed throughout urban locations, the prioritization of NbS should cater for the specific location.

- For example, in urban centers the most welcome and efficient measures combine artificial and natural green amenities, which includes improving access to green spaces and streetscapes simultaneously.

# Takeaways

- Co-benefits to the direct carbon sequestration of NbS should be considered as a potential tool in a wider toolbox when intervening in urban development.

- The role of climate NbS to induce pro-environmental behavior：

- The first is improving streetscapes in the urban center, where active transportation modes can mostly eliminate automobile fuel consumption and where improved built environment design and esthetics, with increased street furniture (especially green streetscapes), can promote walking/cycling.

- The second is creating a protected green belt (preserving suburban green spaces) to reduce urban sprawl and low-density development.

# Takeaways

- The last practice advice is that co-benefits related to social learning and cognitive resilience building should be consider during the planning phase in order to achieve carbon neutrality in urban landscapes.

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# Q&A

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