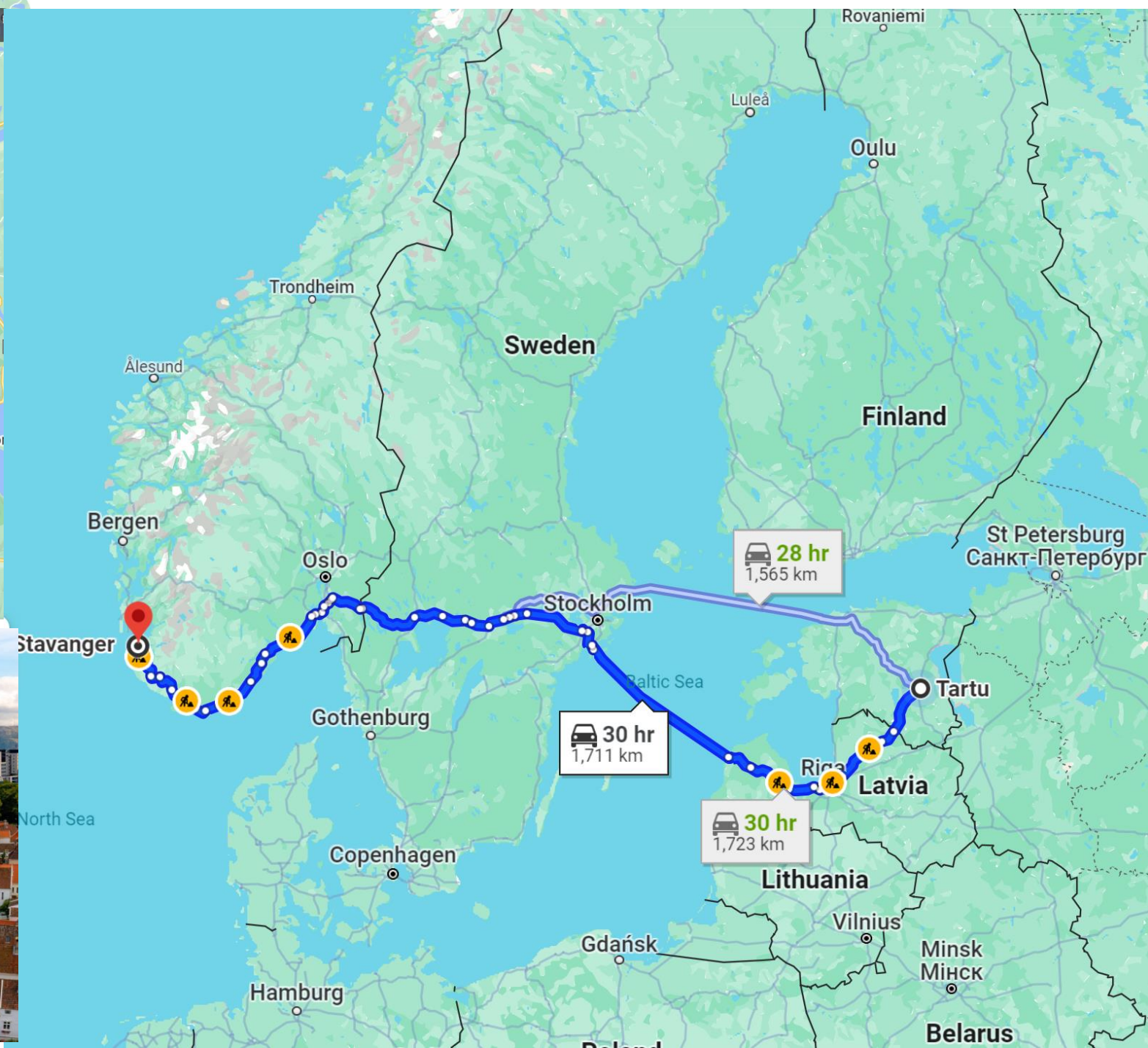
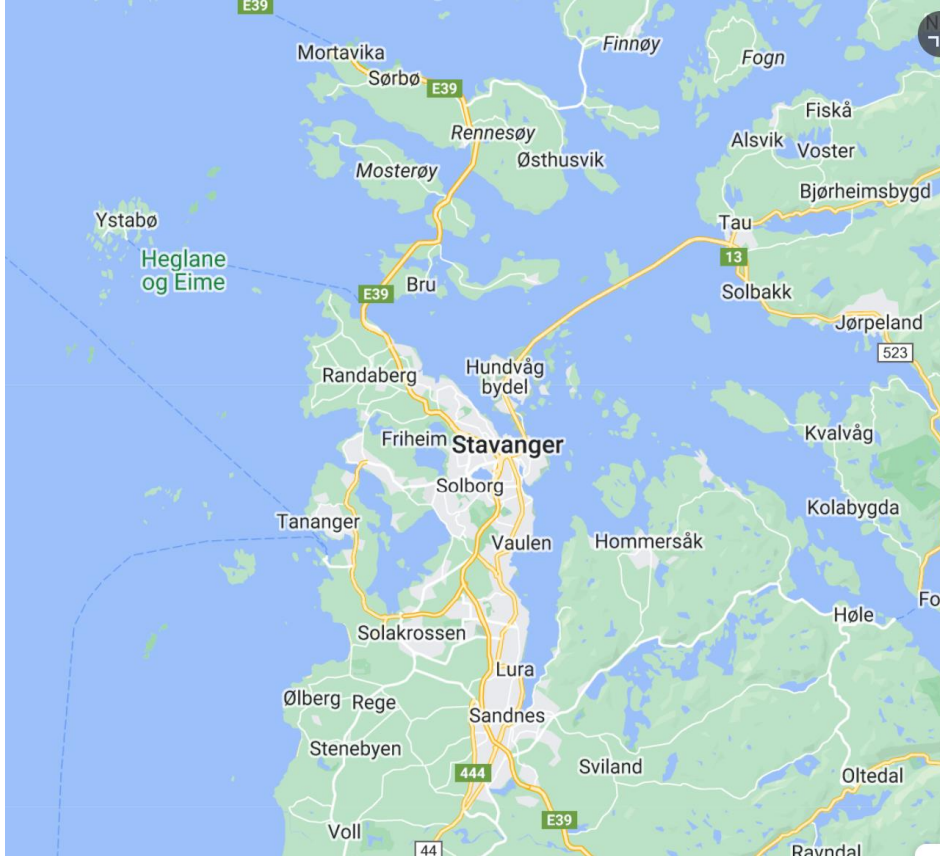


04 June 2024, Tartu, City Blues Partner meeting

Multifunctional green infrastructures for sustainable and livable cities: The case of Stavanger

Ari Tarigan, Maria Korkou, Hans Martin Hanslin



HIGH LEVEL PANEL 4

Reimagining the Role of Finance in Collective Action

The financial sector urgently needs a better understanding of water-related risks. A fundamental rethinking of the role and capacity of collective action is needed, with a focus on universal access to clean water, sanitation and climate resilience. Let's be part of the discussion on how development finance plays an important role in mobilizing collective action to accelerate SDG6 targets.

Keywords:

Finance, Fund, Collective Action, Governance, Civil Society

HIGH LEVEL PANEL 5

Navigating the Source-to-Sea Journey: Advancing Prosperity Across the Entire Water Cycle

Resource-to-ocean management is a game-changing, holistic approach that bridges sectoral and administrative boundaries, seeking to account for and balance social, environmental and economic priorities to achieve multiple benefits.

Please join us to discuss about engagement and strengthening commitment in a holistic ocean resources management approach in addressing global challenges.

Keywords:

Ocean Management, Environment, Sustainability, Commitment, Climate Mitigation, Climate Adaptation

HIGH LEVEL PANEL 6

Hydro-diplomacy and peace

Explore how collaborative water management between communities, sectors and countries can produce a package of shared economic, social and environmental benefits, and promote regional peace and integration. Be the part of this session. Water management collaboration between stakeholders at all levels is a guarantee of sustainable water resources management.

Keywords:

Hydro-Diplomacy, Peace, Cooperation, Shared Prosperity, Sustainable, Transboundary

Concept	Roots/origin and definition	Current focus	Governance focus	Use in urban context	Application in (planning) practice
NbS	New concept, definition still under debate/development	Dealing with multiple societal challenges; biodiversity seen as central to solution	Integrative and governance-based approaches are embraced	Urban focus from the start	Still needs to be developed, but has a strong action focus (problem solving)
GI	Concept with a history of about two decades; in Europe more recent; definition quite well established but also divergent	Broad socio-ecological focus, with major role for landscape architecture and landscape ecology	Participatory planning processes are favoured	Well established	Very well established
ESS	Longest history and definition well established, although still debated	Biodiversity conservation by (economic) valuation of services provided by nature	Focus on governance aspects, participation	Urban ESS have been in focus only more recently	Partly established, but needs operationalisation through other concepts (such as GI, NbS)

Pauleit, S, et al. (2017) Nature-based solutions and climate change – four shades of green. In: Kabisch, N., et al. (eds.) Nature-based solutions to climate change adaptation in urban areas, pp, 29-49, Springer

Nature-based solutions

- Biodiversity and ecosystem services.
- Copy from nature (European Commission 2016).
- Actions to protect, sustainably manage, and restore natural or modified ecosystems
- Trade-off and synergies (International Union for the Conservation of Nature, 2009)
- NBS can provide over one-third of the cost-effective climate mitigation needed between now and 2030
- Stabilising global warming until below 2 °C,
- Achieving nature's mitigation potential of 10-12 gigatons of CO₂ per year.



Blue-green infrastructure

- Blue infrastructure => **water elements**, such as rivers, canals, ponds, wetlands, floodplains, and water treatment facilities.
- Green Infrastructure => **ecological systems**, both natural and engineered, that act as living infrastructure.
- Green and blue infrastructure (GBI) => **the individual parcels of natural space and features** within both our urban and rural spaces that when **connected**, deliver **quality of life** and **environmental benefits** for communities and the nature that thrives within them as a result.



Figure 6. Tanner Springs, a park that collects and purifies stormwater, offers recreational space to residents and provides a habitat for wetland species (Source: (Hansen et al., 2017))

BG infrastructures



Figure 2. Green facade in Oslo (Source: (Oslo kommune, n.d.; Roofs, 2014)), Egenes community garden in Stavanger (Source: (Jensen Erling, 2024)).



Figure 3. Green roof in Oslo (Source: (ByplanOslo, 2019)), Urban forest in Sweden (Source: (Deak-Sjöman, 2020)).

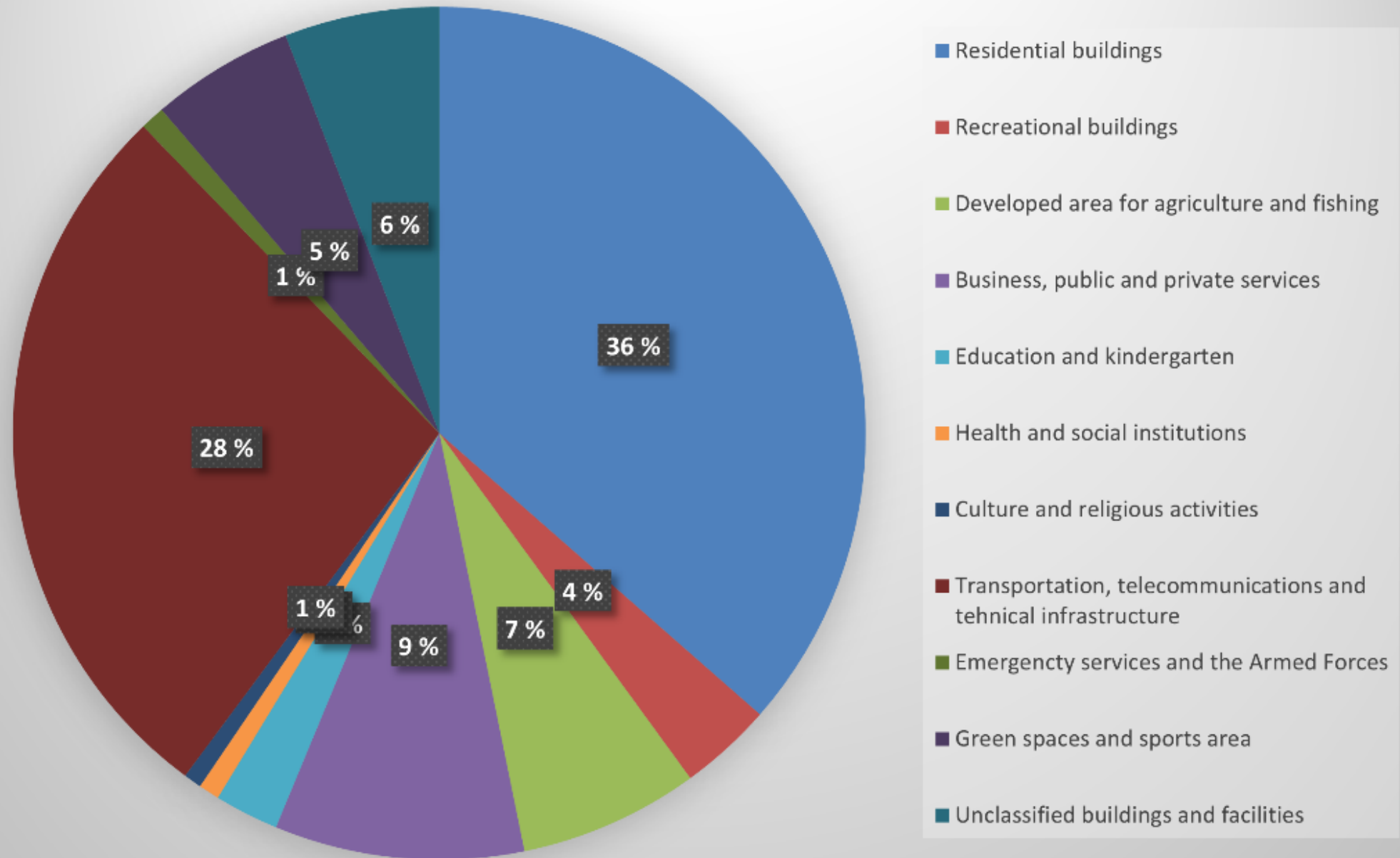


Figure 4. Urban wetland in Oslo. Teglverkesdammen has been formed after the reopening of waterways (Source: (Oslo byleksikon, n.d.)).



Figure 5. The green space of Vålanskogen in Stavanger (left), and the park of Dronningberget, in Bygdøy, in Oslo (right).

Land use and Land resources in Stavanger



Multifunctionality as the key assessment

- NBS and blue-green infrastructure
- Review on green infrastructure multifunctionality
- Assessment of green infrastructure multifunctionality
- ~~○ Interaction between children and nature via green infrastructure~~
- ~~○ Green infrastructure as arena for active learning~~

Multifunctionality in Urban Green Infrastructure: An integrated assessment and exploring the interactions between children and nature

by

Maria Korkou

Thesis submitted in fulfillment of
the requirements for the degree of
PHILOSOPHIAE DOCTOR
(Ph.D.)



Faculty of Science and Technology
Department of Safety, Economics and Planning (ISØP)
2024

Key aspects of multifunctional GI



Review

The multifunctionality concept in urban green infrastructure planning: A systematic literature review

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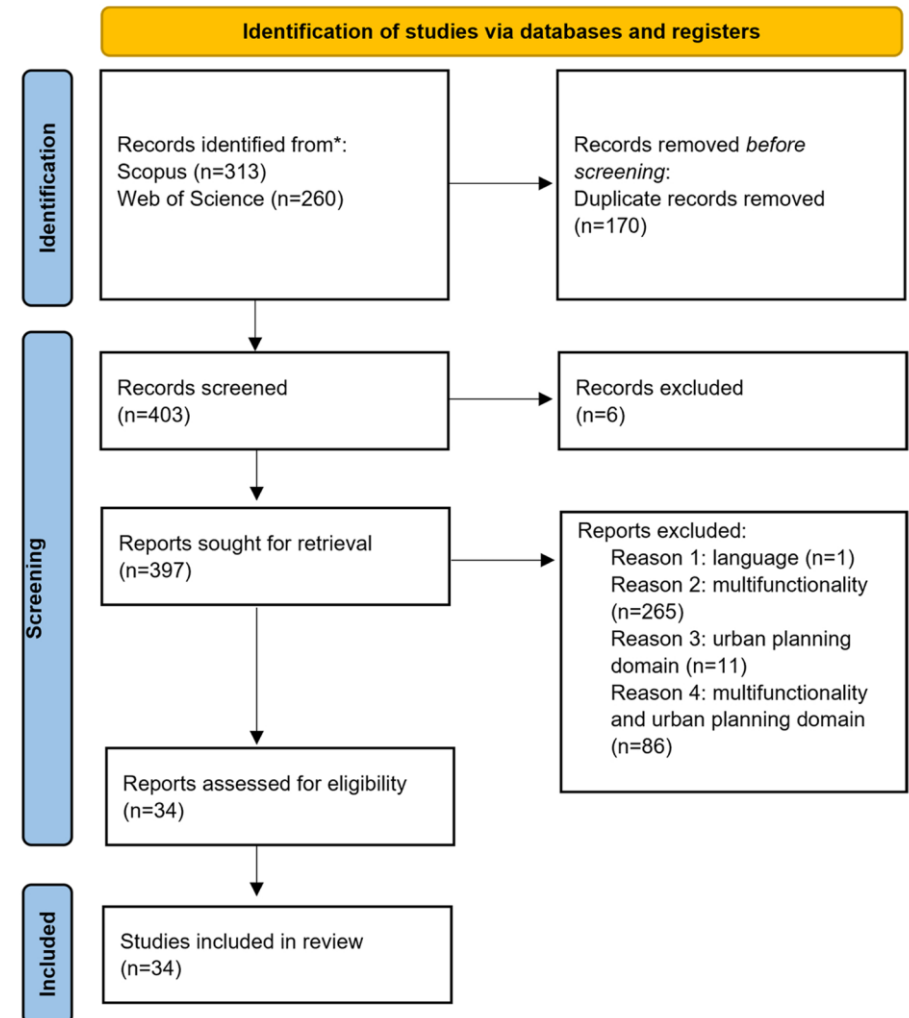
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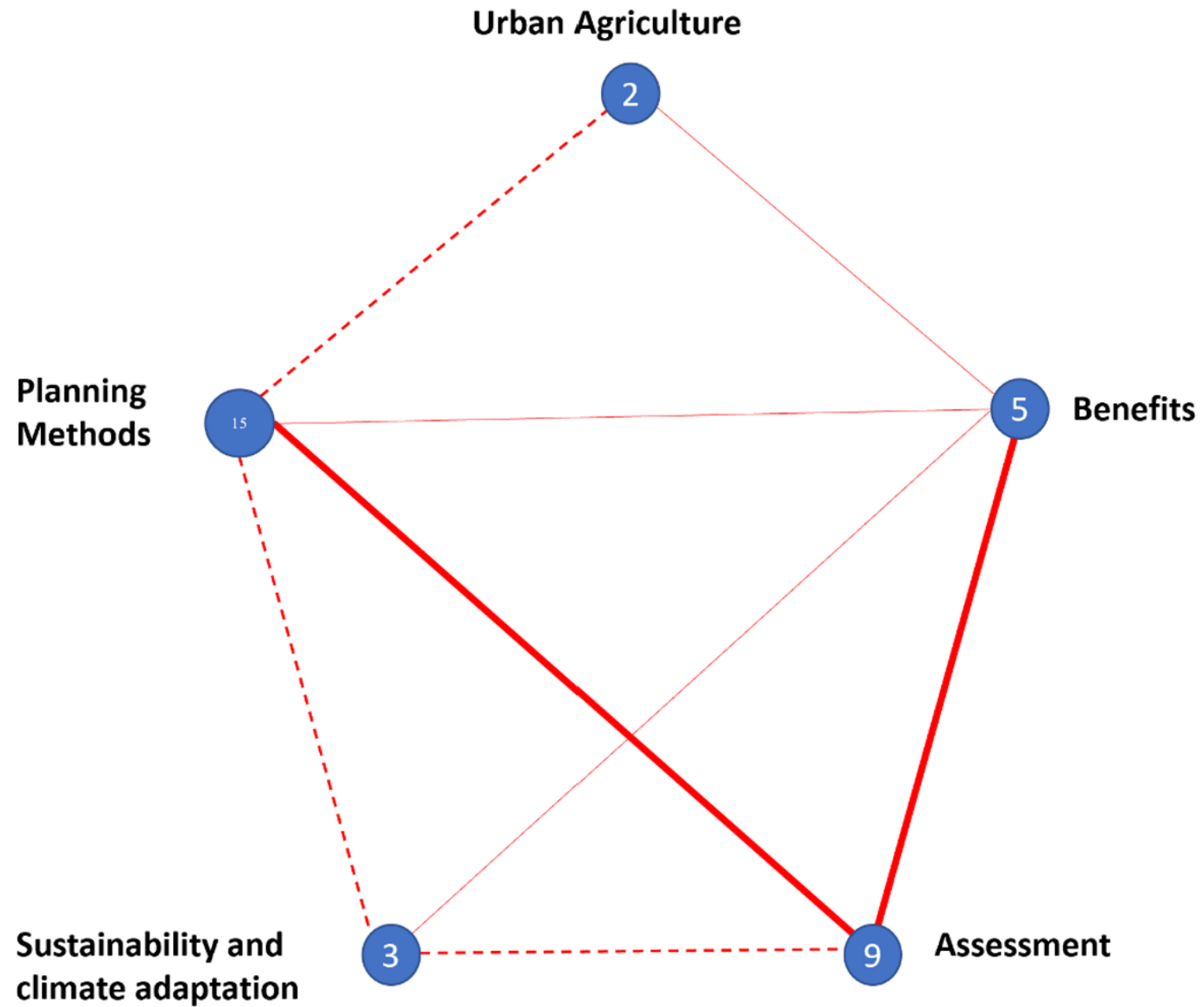
Keywords:

Urban green infrastructure
Multifunctionality
Multiple benefits
Network analysis
Spatial planning

ABSTRACT

Urban green infrastructure is critical for providing a wide range of ecosystem goods and services that benefit the urban population. Past studies have suggested that multifunctionality concerning urban infrastructure services and functions is a prerequisite for targeting effective and impactful urban green infrastructure. Moreover, urban green infrastructure with multiple functions can offer socio-economic and environmental benefits. However, there has been a knowledge gap in the planning literature to elaborate multiple ecosystem functions in urban green infrastructure. In particular, existing methods and approaches are lacking for quantifying and monitoring such ecological services and biodiversity in urban green infrastructures at different spatial scales. Therefore, this research aims to review studies focusing on the multifunctionality concept in urban green infrastructure planning. The study highlights the current status and knowledge gaps through a systematic review. Our analysis revealed that current studies on green infrastructure multifunctionality have focused on five main themes: 1) planning methods for urban green infrastructure, 2) assessment approaches of urban green infrastructure, 3) ecosystem services and their benefits, 4) sustainability and climate adaptation, and 5) urban agriculture. The study found that the five themes are somewhat connected to each other. The study has revealed a knowledge gap regarding incorporating multifunctional green infrastructure in the planning principle. The results suggest at least five critical elements to ensure multiple functions in urban infrastructure. The elements are spatial distribution, optimal distance, integrated network, accessibility, and public participation and engagement. The study further recommends research directions for future analysis on green infrastructure multifunctionality that are critical for urban planning.





Cluster	Description	Keywords	Definition	Resources
1	Planning methods for Multifunctional GI	Planning, land use, master plan, green infrastructure, nature-based solutions, multifunctionality	Methods and approaches to decode and decipher the most effective ways to plan GI multifunctionality.	(García et al., 2020) (Herzog, 2013) (Meerow & Newell, 2017) (Madureira & Andresen, 2013) (Chen et al., 2022) (Taylor et al., 2021) (Goodspeed et al., 2021) (Hansen et al., 2019) (Lewis et al., 2022) (Meerow, 2020) (Van Zyl et al., 2021) (Zidar et al., 2017b) (Wang and Banzhaf, 2018) (Zulian et al., 2021) (Zhang et al., 2019)
2	Approaches to assess GIM	Assessment, measurement, evaluation, multifunctionality	Methods to evaluate the multifunctionality of GI	(Wang et al., 2019) (Tran et al., 2020) (Hansen & Pauleit, 2014) (Santiago-Ramos & Hurtado-Rodríguez, 2022) (Isola et al., 2022) (Pietsch et al., 2021) (Guadie et al., 2022) (Wang and Banzhaf, 2017) (Zhang et al., 2022)
3	Benefits of multifunctionality	Ecosystem services, ecosystem benefits, ecology, multifunctionality	Benefits for humans that are derived directly or indirectly from nature	(Lovell & Taylor, 2013) (Connop et al., 2016) (Wang et al., 2021a) (Kim & Song, 2019) (Lebrasseur (2022))
4	Sustainability and climate adaptation	Sustainability, climate change, mitigation, adaptation	Enhancing the GI multifunctionality as a sustainable solution	(Chamanara & Kazemeini, 2016) (Engström et al., 2018) (Scott et al., 2016))
5	Urban agriculture	Food production, and agricultural landscapes	Cultivating, processing, and distributing food around urban or peri-urban areas	(Rolf et al., 2019) (Tóth & Timpe, 2017)

Korkou et al. 2023

How to assess multifunctional GI?

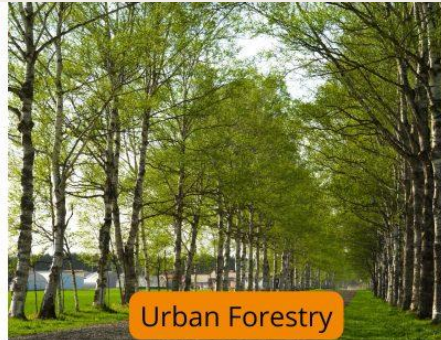
- Korkou et al. Submitted to Landscape and Urban Planning Journal



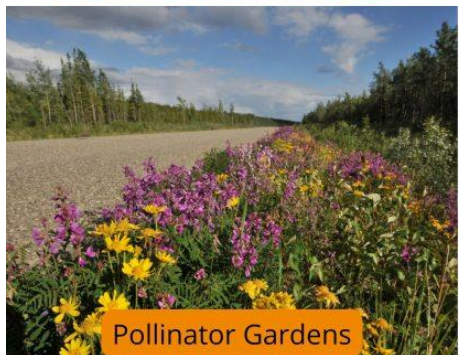
Wetland Restoration



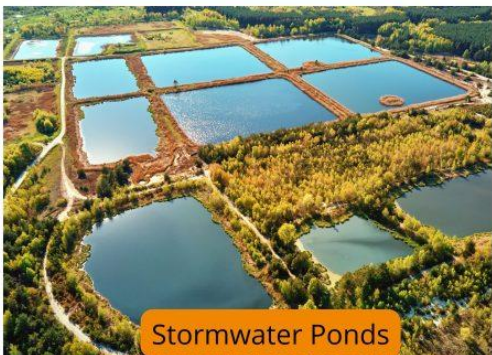
Permeable Pavements



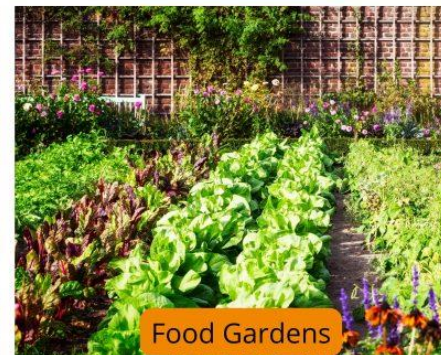
Urban Forestry



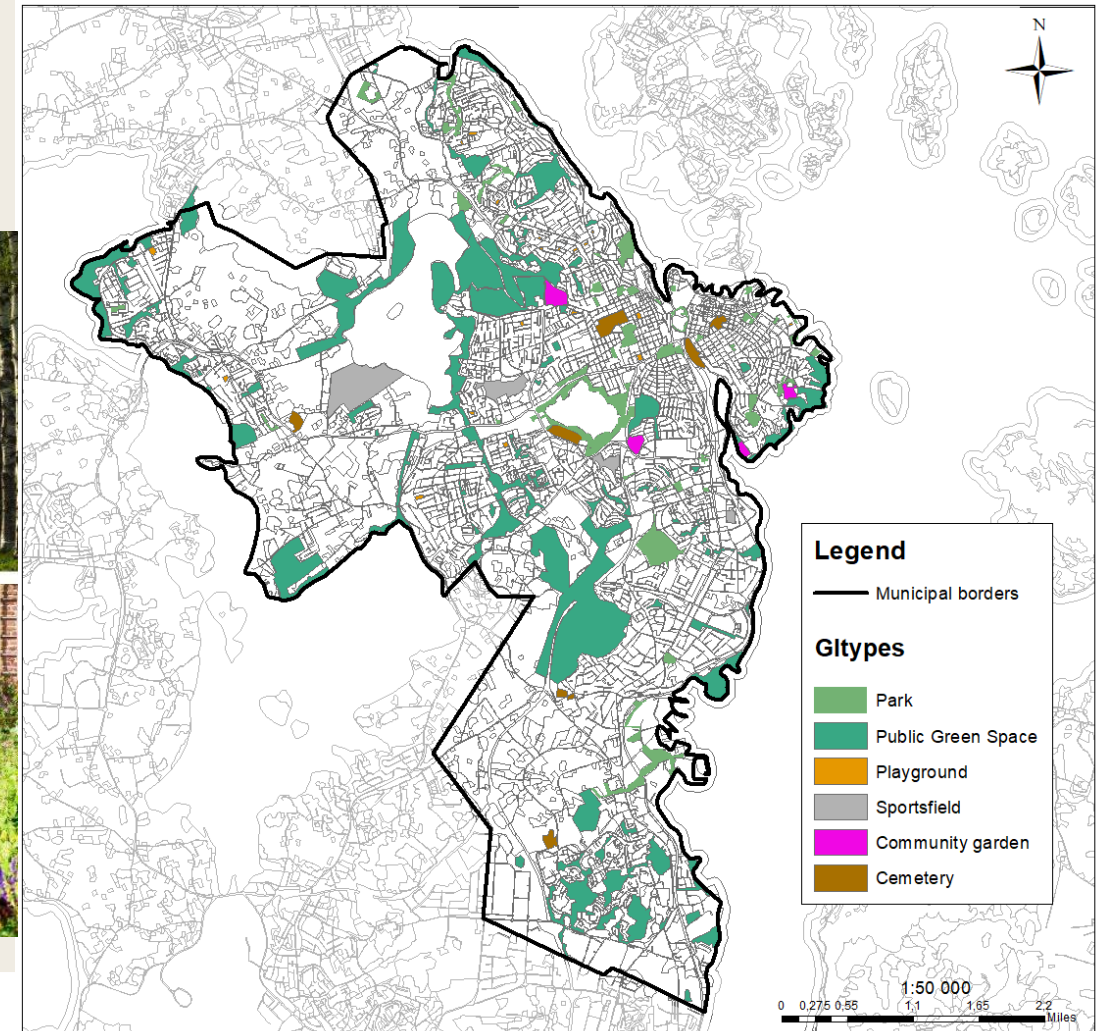
Pollinator Gardens



Stormwater Ponds



Food Gardens



Definition and estimation of function indicators

	Function	Indicator
Cultural services	Social encounters	Social media visibility
Cultural services	Recreational	Sum play features
Cultural services	Accessibility	Seating capacity
Cultural services	Recreational	Water elements
Cultural services	Science	The use for nature observation
Cultural services	Accessibility	Facilities for sports
Cultural services	Accessibility	The total length of the connected path system
Cultural services	Accessibility	Distance to nearest public communication
Cultural services	Accessibility	Path network linkages
Cultural services	Accessibility	Bicycle route
Cultural services	Accessibility	Bicycle parking capacity
Cultural services	Accessibility	Pedestrian areas
Cultural services	Accessibility	Universal design
Cultural services	Educational	Use for education
Cultural services	Cultural information	Number of events
Cultural services	Sense of Heritage	Sculptures outdoors
Cultural services	Sense of Heritage	Archaeological
Cultural services	Sense of Heritage	Religious features
Cultural services	Sense of Heritage	Geological features
Provisioning services	Food production	Food production potential
Regulating services	Stormwater management	Potential water retention
Regulating services	Stormwater management	Drainage lines
Regulating services	Carbon sequestration	Potential C sequestration
Regulating services	Noise mitigation	Silence
Supporting services	Refugium	Habitat for threatened species
Supporting services	Biodiversity support	Indicator species
Supporting services	Biodiversity support	Structural diversity

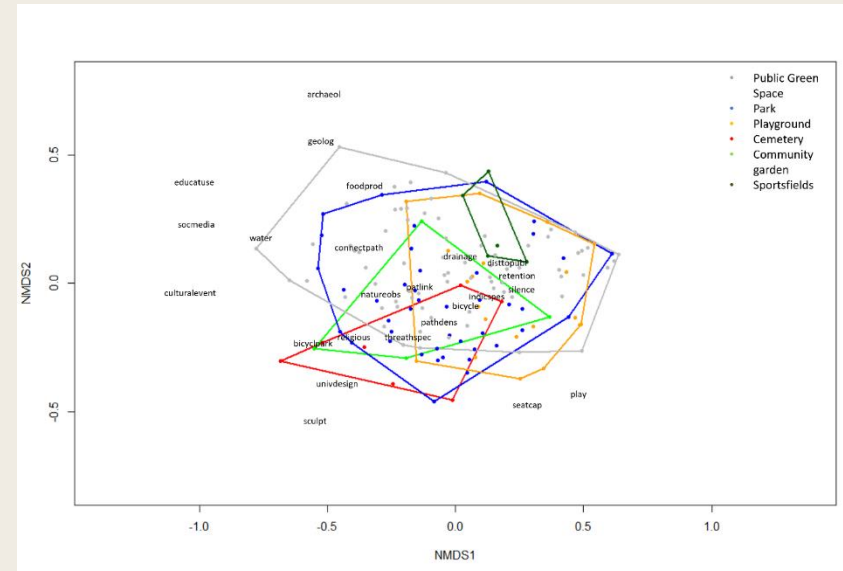
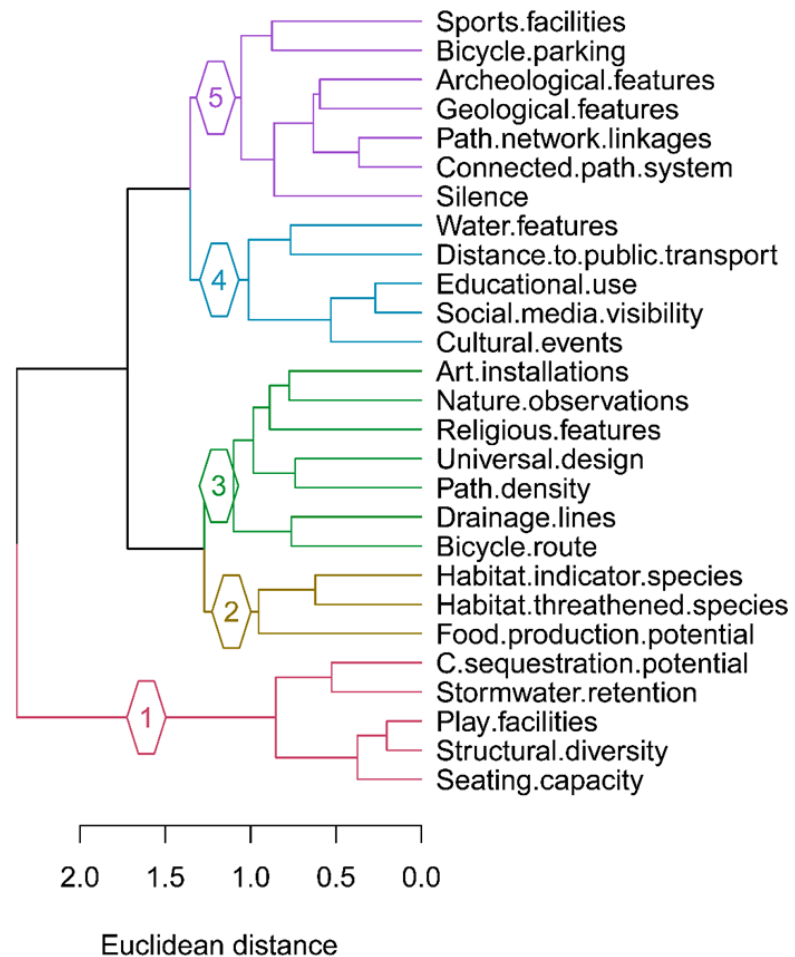
Estimation of multifunctionality

- Each GI unit's multifunctionality was assessed using:
 - the average MF
 - the effective MF
- The average MF was estimated as the arithmetic mean across functions
- The effective MF was estimated using Hill numbers and calculated using the MF package in R
- This index explains the effective number of performed functions and the arithmetic mean of the measured functions
- The estimation of MF was performed for the complete set of 27 indicators, in which 9 indicators explain the core of ecosystem services.
 - These are 1) the use of GI for educational use by nearby schools, 2) the use of the unit for nature observations, 3) potential food production, 4) structural diversity as a proxy for biodiversity potential through heterogeneity, 5) habitats for threatened species, 6) habitats for indicator species, 7) stormwater retention, 8) stormwater drainage lines, and 9) carbon sequestration potential

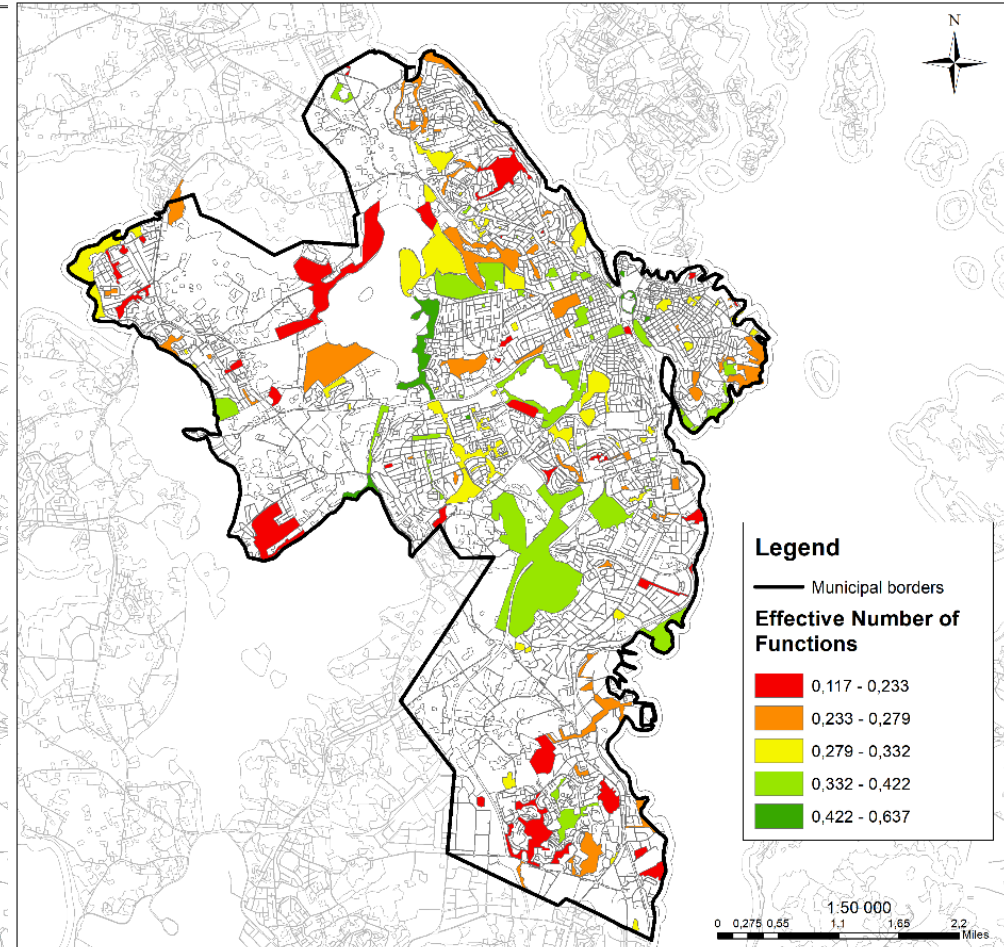
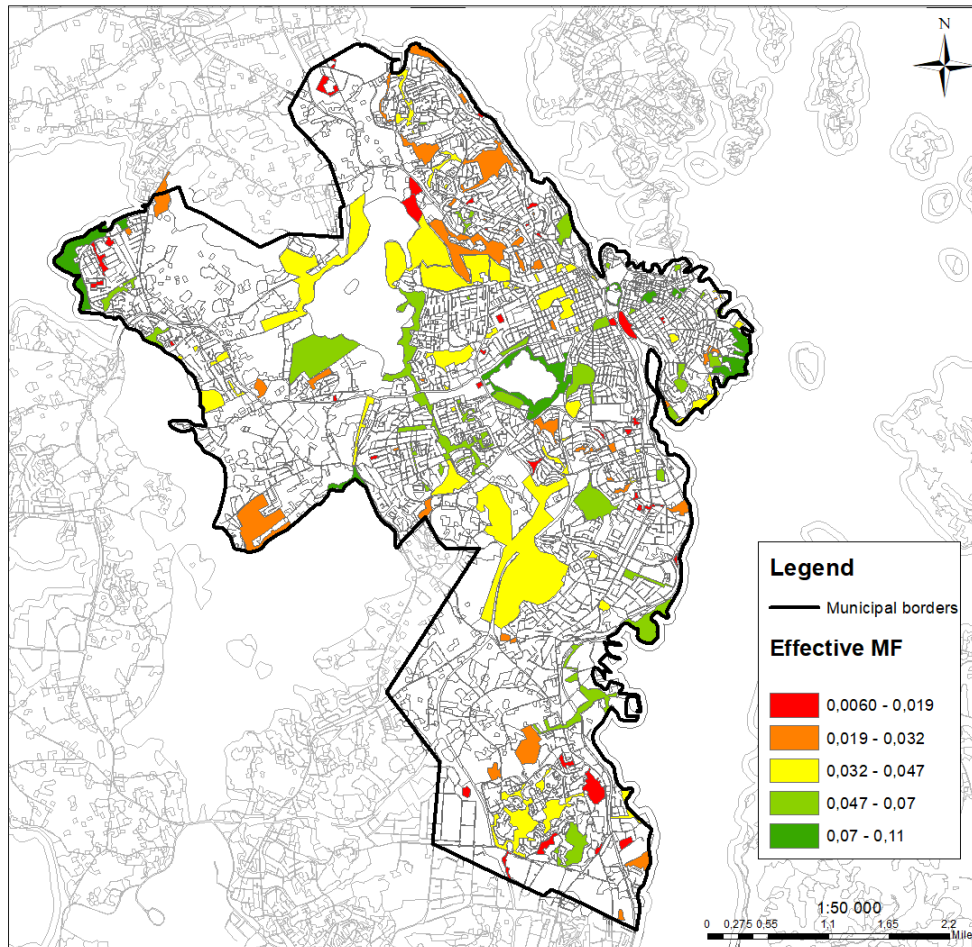
Statistical analyses

- A combination of approaches was utilised to define the structure of the indicator dataset, explore the relationships between indicators and properties of the GI units, and estimate the effective MF.

Correlations and function bundles

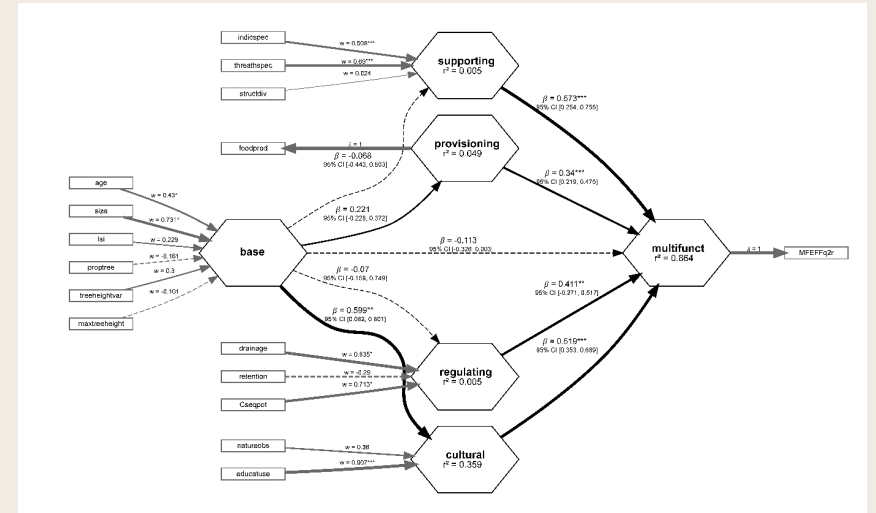


Estimates of multifunctionality



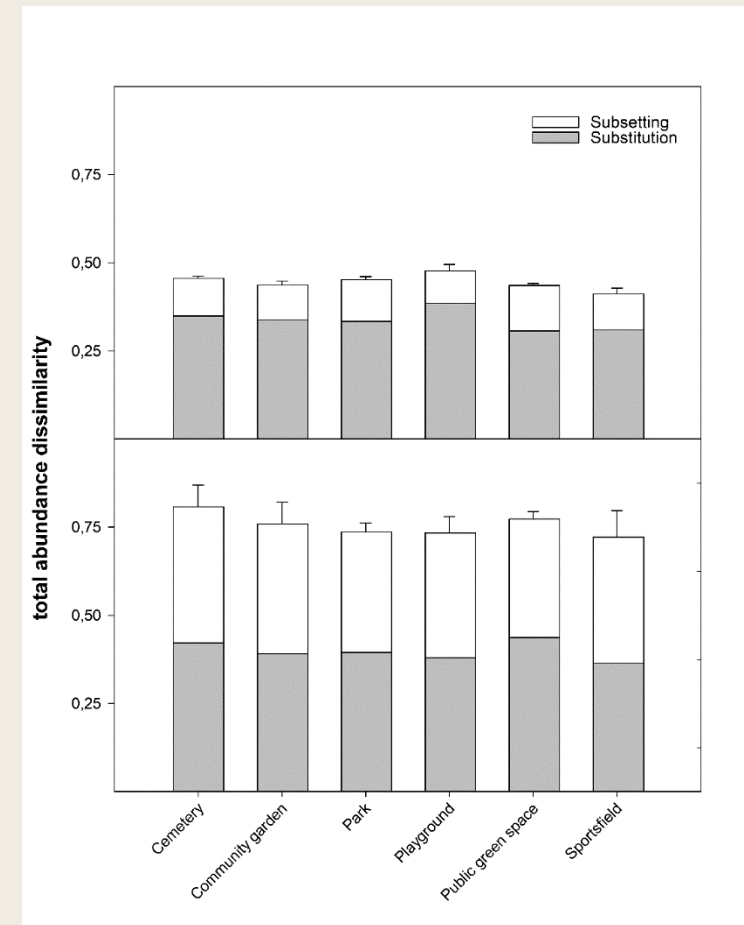
Relationships between effective multifunctionality and site characteristics

- The SEM model revealed variations in support for the different constructs and discrepancies in the weight of the indicators on these constructs.
- Overall, the measurement model demonstrated a moderate fit to the data.
- Concentrating on the core dataset, which contains fewer indicators for cultural functions, resulted in a more balanced contribution to multifunctionality from the supporting, provisioning, regulating, and cultural constructs.
- Incorporating welfare, accessibility, and straightforward supplementary features like seating capacity into the cultural construct reduced the contribution of indicators related to supporting, regulating, and provisioning services.



Contributions to city-wide multifunctionality

- There were similarities across typologies, with the same pattern of subsetting and substituting functions.
- The core data set had a higher degree of function subsetting. The full data set made different contributions to the city-wide MF by providing more unique functions across GI units
- Analysing the relationships between base characteristics and beta diversity indicated that age, shape of the GI unit, and tree-height variation explained a few of the contributions to city-wide MF, but the models were weak.
- In a planning context, the contribution of the base properties to city-wide MF was moderate at best.



Estimates of total function abundance dissimilarity (beta-diversity) for the different types of green infrastructure investigated (means with a half 95% CI) for a full dataset of 27 function indicators (above) and a reduced dataset with 9 core function indicators (below). The total dissimilarity was split between subsetting or substitution of functions across units, where a high proportion of substitution indicated a turnover of functions between units.

Next steps

- From complex assessment to a simple framework
 - Analytical tools for policy makers and business sector
- Experiment to other cities

BLÅGRØNN FAKTOR (BGF) Samarbeidsprosjekt mellom Bærum og Oslo kommune som del av programmet Framtidens byer. Utarbeidet for Bærum og Oslo kommune av Dronninga landskap, COWI og CF Møller. Revidert Oslo kommune 28.01.2014.					
Verdi	Symbol	Faktor	Beskrivelse	Areal m²	BGF
			TOMTENS AREAL (INKLUDERT BEBYGD AREAL). FYLL UT TOMTENS AREAL:	0	
1. BLÅGRØNNE FLATER					
1		ÅPENT PERMANENT VANNSPIL SOM FORDRØYER REGNVANN	Permanente vannspeil som tilføres regnvann fra tomten, uansett om dette er en kanal med betongbunn, bekk med grønne bredder eller annet type vannspeil. Kun selve vannspeilet regnes.	0	0
0,3		DELVIS PERMEABLE FLATER SOM GRUS, SINGEL OG GRESSARMERT DEKKE	Harde overflater med permeabilitet, som sørger for infiltrasjon. For eksempel gressarmering av betong, grus eller singel. Gjelder ikke flater over underliggende harde dekker dersom jorddybden er mindre enn 80 cm.	0	0
0,2		IMPERMEABLE OVERFLATER MED AVRENNING TIL VEGETASJONSAREALER ELLER ÅPENT FORDRØYINGSMAGASIN	F.eks. betong, asfalt, takflater og belegningsstein. Beregnes for areal tilsvarende størrelsen på vegetasjonsflaten som mottar vannet. Fordrøyningsmagasin må ha kapasitet iht. kommunale krav til påslipp til offentlig avløpsnett.	0	0
0,1		IMPERMEABLE OVERFLATER MED AVRENNING TIL LOKALT OVERVANNSANLEGG UNDER TERRENG	F.eks. betong, asfalt, takflater med avrenning som ledes til anlegg under terreng for fordrøynings og rensing av overvannet. Dette gjelder også underjordiske løsninger med kombinert vanning av trær. Hele arealet teller forutsatt at fordrøyningsmagasinet er iht. kommunale krav til påslipp til offentlig avløpsnett.	0	0
1		OVERFLATER MED VEGETASJON FORBUNDET MED JORD ELLER NATURLIG FJELL I DAGEN	Vegetasjon som vokser i jord og har kontakt med jorden under. Gunstig for utvikling av flora og fauna og for vann som kan trekke ned til grunnvannet. Punktet gjelder også for naturlige fjellknauser og svaberg.	0	0
0,8		OVERFLATE MED VEGETASJON, IKKE FORBUNDET MED JORD >80 cm	Vegetasjon som vokser i jord på min. 80 cm dybde, men som ikke har kontakt med jorden/grunnen under; f.eks. oppå et garasjeanlegg eller tak. Dybden er stor nok til at større trær kan vokse.	0	0
0,6		OVERFLATE MED VEGETASJON, IKKE FORBUNDET MED JORD 40-80 cm	Som over, men med 40-80 cm jord for at hekker, store busker og små og mellomstore trær kan vokse.	0	0
0,4		OVERFLATE MED VEGETASJON, IKKE FORBUNDET MED JORD 20-40 cm	Som over, men med 20-40 cm jord for mulig vekst av stauder og små busker.	0	0
0,2		OVERFLATE MED VEGETASJON, IKKE FORBUNDET MED JORD 3-20 cm	Som over, men med 3-20 cm jord, for mulig vekst av sedum, gress, og markdekkere.	0	0

BLÅGRØNN FAKTOR (BGF) Samarbeidsprosjekt mellom Bærum og Oslo kommune som del av programmet Framtidens byer. Utarbeidet for Bærum og Oslo kommune av Dronninga landskap, COWI og CF Møller. Revidert Oslo kommune 28.01.2014.					
Verdi	Symbol	Faktor	Beskrivelse	Areal m²	BGF
			TOMTENS AREAL (INKLUDERT BEBYGD AREAL). FYLL UT TOMTENS AREAL:	0	
1. BLÅGRØNNE FLATER					
1		ÅPENT PERMANENT VANNSPIL SOM FORDRØYER REGNVANN	Permanente vannspeil som tilføres regnvann fra tomten, uansett om dette er en kanal med betongbunn, bekk med grønne bredder eller annet type vannspeil. Kun selve vannspeilet regnes.	0	0
0,3		DELVIS PERMEABLE FLATER SOM GRUS, SINGEL OG GRESSARMERT DEKKE	Harde overflater med permeabilitet, som sørger for infiltrasjon. For eksempel gressarmering av betong, grus eller singel. Gjelder ikke flater over underliggende harde dekker dersom jorddybden er mindre enn 80 cm.	0	0
0,2		IMPERMEABLE OVERFLATER MED AVRENNING TIL VEGETASJONSAREALER ELLER ÅPENT FORDRØYINGSMAGASIN	F.eks. betong, asfalt, takflater og belegningsstein. Beregnes for areal tilsvarende størrelsen på vegetasjonsflaten som mottar vannet. Fordrøyningsmagasin må ha kapasitet iht. kommunale krav til påslipp til offentlig avløpsnett.	0	0
0,1		IMPERMEABLE OVERFLATER MED AVRENNING TIL LOKALT OVERVANNSANLEGG UNDER TERRENG	F.eks. betong, asfalt, takflater med avrenning som ledes til anlegg under terreng for fordrøynings og rensing av overvannet. Dette gjelder også underjordiske løsninger med kombinert vanning av trær. Hele arealet teller forutsatt at fordrøyningsmagasinet er iht. kommunale krav til påslipp til offentlig avløpsnett.	0	0
1		OVERFLATER MED VEGETASJON FORBUNDET MED JORD ELLER NATURLIG FJELL I DAGEN	Vegetasjon som vokser i jord og har kontakt med jorden under. Gunstig for utvikling av flora og fauna og for vann som kan trekke ned til grunnvannet. Punktet gjelder også for naturlige fjellknauser og svaberg.	0	0
0,8		OVERFLATE MED VEGETASJON, IKKE FORBUNDET MED JORD >80 cm	Vegetasjon som vokser i jord på min. 80 cm dybde, men som ikke har kontakt med jorden/grunnen under; f.eks. oppå et garasjeanlegg eller tak. Dybden er stor nok til at større trær kan vokse.	0	0
0,6		OVERFLATE MED VEGETASJON, IKKE FORBUNDET MED JORD 40-80 cm	Som over, men med 40-80 cm jord for at hekker, store busker og små og mellomstore trær kan vokse.	0	0
0,4		OVERFLATE MED VEGETASJON, IKKE FORBUNDET MED JORD 20-40 cm	Som over, men med 20-40 cm jord for mulig vekst av stauder og små busker.	0	0
0,2		OVERFLATE MED VEGETASJON, IKKE FORBUNDET MED JORD 3-20 cm	Som over, men med 3-20 cm jord, for mulig vekst av sedum, gress, og markdekkere.	0	0
2. BLÅ OG GRØNNE TILLEGGSKVALITETER. GIR EKSTRAPOENG. DET SAMME AREALET KAN DERFOR TELLES FLERE GANGER.					
BLÅ TILLEGGSKVALITETER					
0,3		NATURLIGE BREDDER TIL VANNSPIL	Åpent vannspeil med naturlige bredder telles med i denne kategorien dersom det er tilgjengelig for flora/fauna i bakkenivå og har naturlig bunnsstrukt og kantsone. F.eks. bekk, kanal og dam med grønne bredder. Arealet som regnes er bredden til vannspeilet.	0	0
0,3		REGNBED ELLER TILSVARENDE	Vegetasjonsareal som fungerer som regnbett eller tilsvarende beplantet infiltrasjonsløsning som samler opp, fordrøyer og infiltrerer regnvann ned i jorden/grunnen. Dette gjelder ikke permanente vannspeil og fordrøyningsbasseng som telles i blå flater.	0	0
GRØNNE TILLEGGSKVALITETER, PUNKTENE UNDER (TRÆR) SKAL FYLLES INN SOM STYKK				STK	
1		EKSISTERENDE STORE TRÆR >10 m	Eksisterende store trær; over 10 m. Faktor: 25 m²/træ.		0
0,8		EKSISTERENDE TRÆR SOM FORVENTES BLI >10 m	Eksisterende trær som blir over 10 meter høye. Skogstrær, edelløvtrær og parktrær, som f.eks; alm, ask, bjørk, eik, lind, lønn, kastanje, furu og mange flere. Det forventes at treet skal ha nok jord til å vokse (min 100 cm). Faktor: 25 m²/træ (x 0,8).	0	0
0,6		EKSISTERENDE TRÆR SOM BLIR SMÅ/MELLOMSTORE (5-10 m)	Eksisterende trær som er 5-10 meter høye. Prydtrær og frukttrær, f.eks; apal, kirsebær, magnolia, pæretrær, robinia og mange flere. Gjelder også formklippede trær. Det forventes at treet skal ha nok jord til å vokse (min 60 cm). Faktor: 16 m²/træ (x 0,6).	0	0
0,7		NYPLANTEDE TRÆR SOM FORVENTES BLI >10 m	Trær som blir over 10 meter høye. Art: Se to spalter over. Det forventes at treet skal ha nok jord til å vokse (min 100 cm). Faktor: 25 m²/træ (x 0,7).	0	0
0,5		NYPLANTEDE TRÆR SOM FORVENTES BLI SMÅ/MELLOMSTORE (5-10 m)	Trær som blir 5-10 meter høye. Art: Se to spalter over. Det forventes at treet skal ha nok jord til å vokse (min 60 cm). Faktor: 16 m²/træ (x 0,5).	0	0
PUNKTENE UNDER SKAL FYLLES INN SOM m²				Areal m²	
0,6		STEDEGEN VEGETASJON	Etablering eller vern av overflater med stort innslag av verdifulle plantearter som inngår i det lokale, historiske natur- og kulturlandskapet.	0	0
0,4		HEKKER, BUSKER OG FLERSTAMMEDE TRÆR	Hekker, busker og flerstammede trær beregnes maksimalt for dryppsonen til busken, kronens utstrekning.	0	0
0,4		GRØNNE VEGGER	For klatreplanter og andre grønne vegger regnes veggarealet som forventes å være dekket i løpet av 5 år (maks 10 m i høyde for klatreplanter).	0	0
0,3		STAUDER OG BUNNDEKKERE	Gjelder ikke plen eller sedum.	0	0
0,1		SAMMENHENGENDE GRØNTAREALER OVER 75 m²	Sammenhengende grøntareal som er større enn 75 m², som for eksempel store gressplener, plantefelt eller annet.	0	0
PUNKTENE UNDER SKAL FYLLES INN MED TALLET 0,05				0,05	
0,05		KOBLING TIL EKSISTERENDE BLÅGRØNN STRUKTUR	Dersom blå og/eller grønne elementer i området kobles til eksisterende blågrønn struktur utenfor området. Sammenheng skal være tydelig. For eksempel en bekkeåpning, en kobling til eksisterende kanal eller vannspeil, flomvei, forlengelsen av en allé eller et skogholt, sammenslåing av flere gårdsrom med fri ferdsel mellom dem. Dette gir et generelt tillegg på 0,05 i BGF.	0	0
TOTAL BLÅGRØNN FAKTOR (BGF)				###	

For Excel-versjon se vedlegg 1.

” Thank you

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