

Dense and Green Cities for a Nature-Positive Future

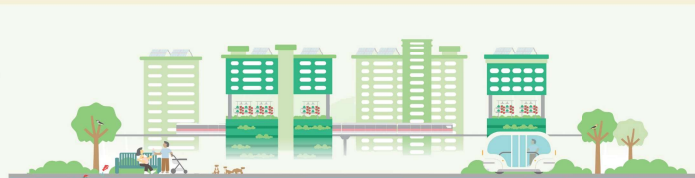


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**URBAN SOLUTIONS
AND SUSTAINABILITY**
R&D CONGRESS 2023
BUILDING SUSTAINABLE, RESILIENT, AND LIVEABLE CITIES OF TOMORROW
4TH - 5TH OCTOBER 2023



CREATE *ETH zürich*



**(FCL) FUTURE
CITIES
LABORATORY
GLOBAL**

Singapore Green Plan 2030

City in Nature Vision

- one of the 6 critical pillars for achieving net zero targets by 2050
- intensify nature in gardens and parks
- restore nature into the urban landscape
- strengthen connectivity between Singapore's green spaces and urban systems
- shared ecosystem for all – shift from 'people-centric' to 'life-centric'

2023

SG GREEN PLAN

The Singapore Green Plan 2030 is a national sustainability movement, positioning us to achieve our target of net zero emissions by 2050. It is a living plan which continues to evolve. Here are the key updates and initiatives announced by Green Plan Ministries in Committee of Supply 2023.

GreenPlan.gov.sg



Jointly led by: Ministry of Education, AMND, Ministry of Sustainability and the Environment, MTI, Ministry of Trade and Industry, Ministry of Transport

SG GREEN PLAN

The Singapore Green Plan 2030 is a national sustainability movement which seeks to rally bold and collective action to tackle climate change.

It is a living plan which will evolve as we work with Singaporeans and partners from all sectors to co-create solutions for sustainability. Let's work together to make Singapore a green and liveable home.

City in Nature

- Green, Liveable and Sustainable Home for Singaporeans**
- Plant 1 million more trees, and have every household within a 10-minute walk from a park by 2030
 - Develop over 130 ha of new parks, and enhance around 170 ha of existing parks with more lush vegetation and natural landscapes by end-2025
 - Add 1000ha of green spaces by 2035

Green Government

- Public sector will lead on sustainability**
- Be exemplary in taking sustainability action, including to peak public sector carbon emissions around 2025, ahead of national target
 - Encourage and enable citizens and businesses to adopt sustainability practices, such as through green procurement

Sustainable Living

- Strengthen Green Efforts in Schools**
- Introduce an Eco Stewardship Programme to enhance environmental education in all schools
 - Work towards two-thirds reduction of net carbon emissions from schools sector by 2030
 - At least 20% of schools to be carbon neutral by 2030

Green Commutes

- 75% of trips during peak periods to be on mass public transport by 2030
- Triple cycling path network to 1,320km by 2030, from 460km in 2020
- Expand rail network to 360km by early 2030s, from around 230km today

Green Citizenry:

- Reduce waste and consumption**
- Reduce amount of waste to landfill per capita per day by 20% by 2025, and 30% by 2030
 - Reduce household water consumption to 130 litres per capita per day

Energy Reset

- Cleaner-energy Vehicles**
- New diesel car and taxi registrations to cease from 2025, with all new car and taxi registrations to be of cleaner-energy models from 2030
 - Further revise road tax structure to bring down road tax for mass-market electric cars
 - Target 60,000 electric vehicle (EV) charging points by 2030, with 8 EV-Ready Towns by 2025

Greener Infrastructure & Buildings

- Green 80% of Singapore's buildings (by Gross Floor Area) by 2030
- 80% of new buildings (by Gross Floor Area) to be Super Low Energy buildings from 2030
- Best-in-class green buildings to see 80% improvement in energy efficiency (over 2005 levels) by 2030

Sustainable Towns & Districts

- Reduce energy consumption in HDB towns by 15% by 2030
- Green Energy**
- Quadruple solar energy deployment to 1.5 gigawatt-peak by 2025
 - Tap on cleaner electricity imports, and increase R&D on renewable energy and emerging low-carbon technologies

Green Economy

- Sustainability as New Engine of Jobs and Growth**
- New Enterprise Sustainability Programme to help local enterprises adopt sustainability practices
 - Develop Singapore to be a carbon services hub, and a leading centre for green finance in Asia and globally
 - Develop Jurong Island to be a sustainable energy and chemicals park
 - Leverage opportunities in sustainable industries to create good jobs for Singaporeans
- New Investments to be Carbon and Energy Efficient**
- Seek new investments to be among the best-in-class in energy/carbon efficiency

Resilient Future

- Safeguarding our Coastlines against Rising Sea Levels**
- \$55b dedicated to coastal and drainage flood protection measures
 - Formulation of coastal protection plans for City-East Coast, North-West Coast (Lim Chu Kang and Sungei Kadut) and Jurong Island by 2030
- Safeguarding Food Security**
- Develop the capability and capacity of our local agri-food industry to produce 30% of our nutritional needs locally and sustainably by 2030
- Keeping Singapore Cool**
- Moderate the rise in urban heat, such as with cool paint and by increasing greenery

Jointly led by:



www.GreenPlan.gov.sg

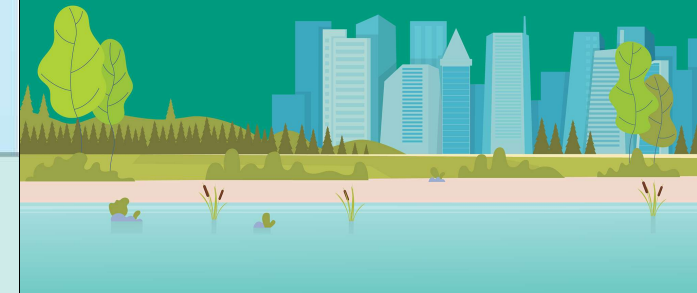
Updated 19 Aug 2023

2023

CITY IN NATURE

CONSERVING OUR BIODIVERSITY

- Increase the target for restoration and enhancement of forest, coastal and marine habitats from 30 hectares to 80 hectares by 2030, to help our native biodiversity thrive in our ecosystem



Dense and Green Cities for a Nature – Positive Future

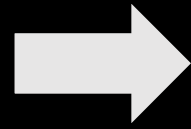
Dense and Green Paradigm

Singapore – Capital City for Vertical Greenery*

Greenery becoming a key component to making high-density urban environments liveable
Density and Sustainability become mutually beneficial and interdependent

VERTICAL CITIES

Vertical Living as Sustainable Urban Solution



DENSE + VERTICAL + GREEN

Liveability: Key Measure for Sustainable Dense and Green Cities

emergence of a three-dimensional urban space, where “the horizontal ground plane of a city begins to ‘thicken’, and growth is through vertical densification in addition to lateral spread” (Cairns, 2016).

“the need to see cities as dense and green spaces where integrating ecological principles within high-density urban planning has proven that in most liveable cities, density and quality of life were not mutually exclusive, but rather mutually beneficial” (Schroepfer, 2016, 2



Density Complexity Verticality

Vertical extensions of urban greenery

Elevated urban green networks adding new dimensions of public space for high-density cities

Urban intensifications in the form of vertical urban planning and design have taken on a more ecological discourse in the context of global climate change, with integrated vertical urban greenery gaining significance as a critical planning and development tool for ‘vertical cities’ to achieve a high-quality living environment that balances ecology, sustainability and liveability.

Cairns, S. (2016). 3D City, 2D Urbanity? The Singapore Architect, 04, 91–94.
Schroepfer, T. (2020). Dense + Green Cities: Architecture As Urban Ecosystem (1st edition). Birkhäuser.
* See a+u 2012.

Sustainable to Regenerative

Urban Ecosystems Approach

- Urban developments are driven by solutions that are environmentally enhancing and establish restorative relationships with the natural systems
- Creating cities functioning as living systems, where human activities align with natural processes and cycles.

Systems and process connect

Dynamic interactions between human and nature
Urban nature, where humans become an integral part of the natural processes and contribute positively to ecological balance

Net-positive design

Designs that are driven towards contributing positively to the natural environment, going beyond doing less damage or a net-zero approach

Changing the transformational scales

Shifting deeper into the realms of sustainability and taking a holistic view of a thriving living process (natural + human)
Social, ecological, environmental systems work together instead of against or at the cost of each other

Performance-based Design

Research driven scientific approach to informed design practice
Integrate new tools and methods for predictive planning and design

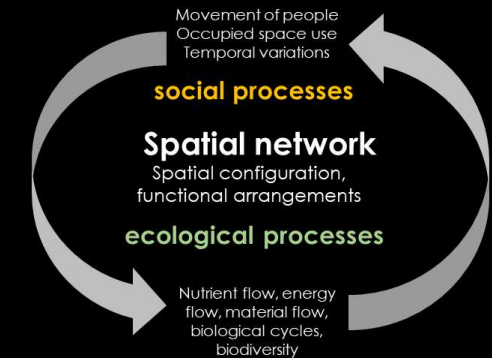
Placemaking to Placekeeping

Building social resilience through biophilic communities
Adding a layer of responsibility to the sense of belonging
Engaging long-term as an integral part of the life cycle

- self-regulating
 - biological processes
 - outside the manufactured realm
- self-sustaining
 - adaptable and resilient



- built for performing specific function
- mechanical processes
- manufactured realm
- not self-sustaining by itself
- not adaptable and resilient by itself



natural systems

built systems

urban ecosystems

ecological and anthropogenic systems are mutually dependent and beneficial

Performative Buildings

Dense and Green Building Typologies (2019)

- Key collaborators were SUTD, ETH Zurich, NParks, CLC, BCA, URA, HDB
- The study systematically analysed the dense and green building typologies' environmental, social, architectural, economic, and aesthetic benefits and their potential to function as part of a larger urban landscape ecosystem.

DENSE AND GREEN CITIES Architecture as Urban Ecosystem

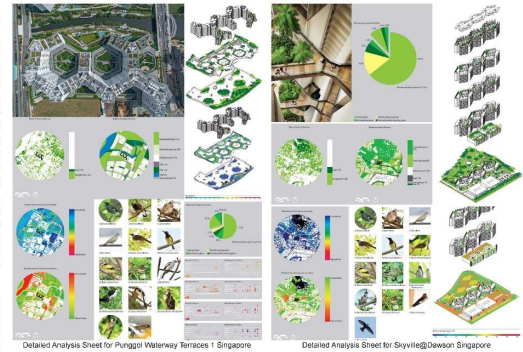
The presented research explored the interaction between buildings and the city as ecological systems through the questions of concept, planning, design, technology and not least experience. The study evaluated the dense and green building typologies for their urban, architectural, social, environmental, ecological and economic benefits. The insights gained were consolidated as design strategies in that the integration of green and public spaces becomes integral to the design and form of buildings and not merely functional additions. This included structural considerations as well as considerations regarding the integration with other building systems. The initial explorations involved multi-dimensional analysis of 600 national and international dense and green projects. Six in-depth case studies were identified for detailed research. The project was multidisciplinary, requiring expertise in urban planning, urban design, architecture, landscape architecture, building technology, social sciences and plant ecology. The study concluded that dense and green buildings are effective in the provisioning, regulating, socio-cultural, supporting and economic services in dense urban environments. In addition, when connected and becoming part of larger urban ecological systems, these integrated developments can potentially produce additional benefits at a larger scale.



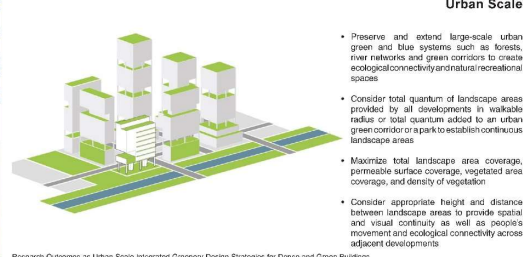
Exhibitions - FCI Dense and Green Building Typologies Architecture as Urban Ecosystem at Venice Architecture Biennale 2018



Exhibitions - Dense and Green Cities Architecture as Urban Ecosystem at National Design Centre Singapore, 2020



Detailed Analysis Sheet for Punggol Waterway Terraces 1 Singapore



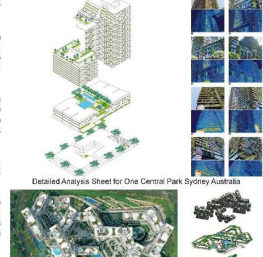
Detailed Analysis Sheet for Skyville@Dawson Singapore



Detailed Analysis Sheet for Oasia Downtown Singapore



Detailed Analysis Sheet for One Central Park Sydney Australia



Detailed Analysis Sheet for Khoo Teck Puat Hospital Singapore



Detailed Analysis Sheet for Skyville @ Dawson Singapore



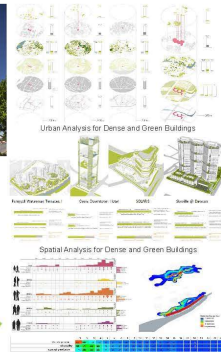
Detailed Analysis Sheet for Punggol Waterway Terraces 1 (Public Residential) Singapore



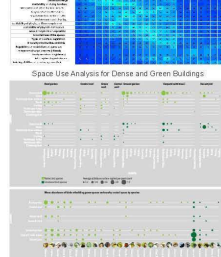
Detailed Analysis Sheet for Khoo Teck Puat Hospital (Hospital) Singapore



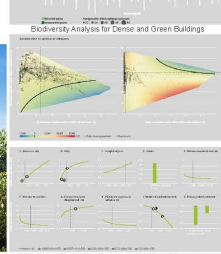
Detailed Analysis Sheet for Solaris (Office) Singapore



Detailed Analysis Sheet for The Interlace (Private Residential) Singapore



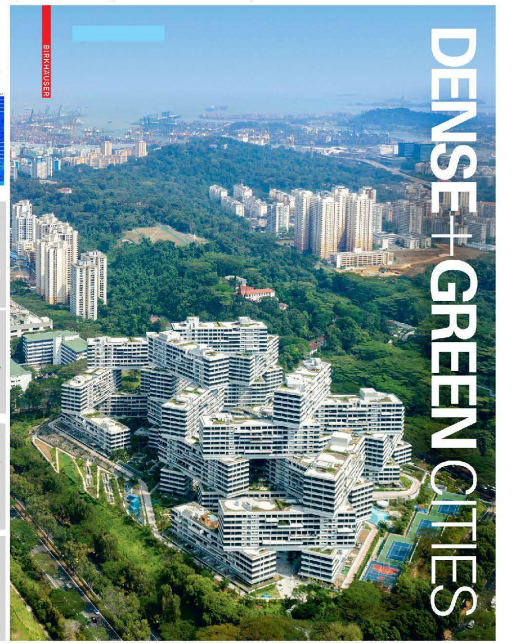
Detailed Analysis Sheet for Oasia Downtown (Mixed-Use) Singapore



Detailed Analysis Sheet for Skyville @ Dawson (Public Residential) Singapore

DENSE AND GREEN CITIES Architecture as Urban Ecosystem

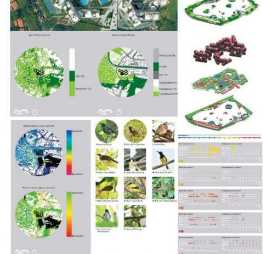
Innovative building projects in high-density urban environments show that density and sustainability are not necessarily contradictory. In fact, they can be mutually dependent and synergistic. For the past six years, the Dense and Green Cities research project at the Swiss Federal Institute of Technology Zurich (ETHZ), the Singapore University of Technology and Design, and the Singapore-ETH Centre Future Cities Laboratory has explored exemplary urban developments throughout the world that demonstrate possible interactions between 'green' buildings and the city as ecological systems and the many design, environmental, social, and economic benefits the resulting dense and green cities offer. The project has developed innovative methods and tools that allow for dense and green buildings to support higher urban standards of environmental sustainability as well as enhanced urban resilience and liveability and it has resulted in many presentations, exhibitions, and publications including most recently Dense and Green Cities: Architecture as Urban Ecosystem, published by Birkhäuser in 2020 (DOI: <https://doi.org/10.1515/9783035615111>).



Dense and Green Cities Architecture as Urban Ecosystem, published by Birkhäuser in 2020



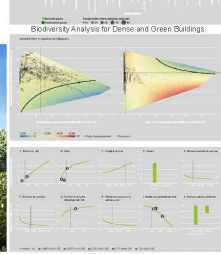
Research Outcomes and Contributions in the form of Book Publications



Future Cities Lab Indicia



Eight Identified In-Depth Case Studies of Dense and Green Buildings



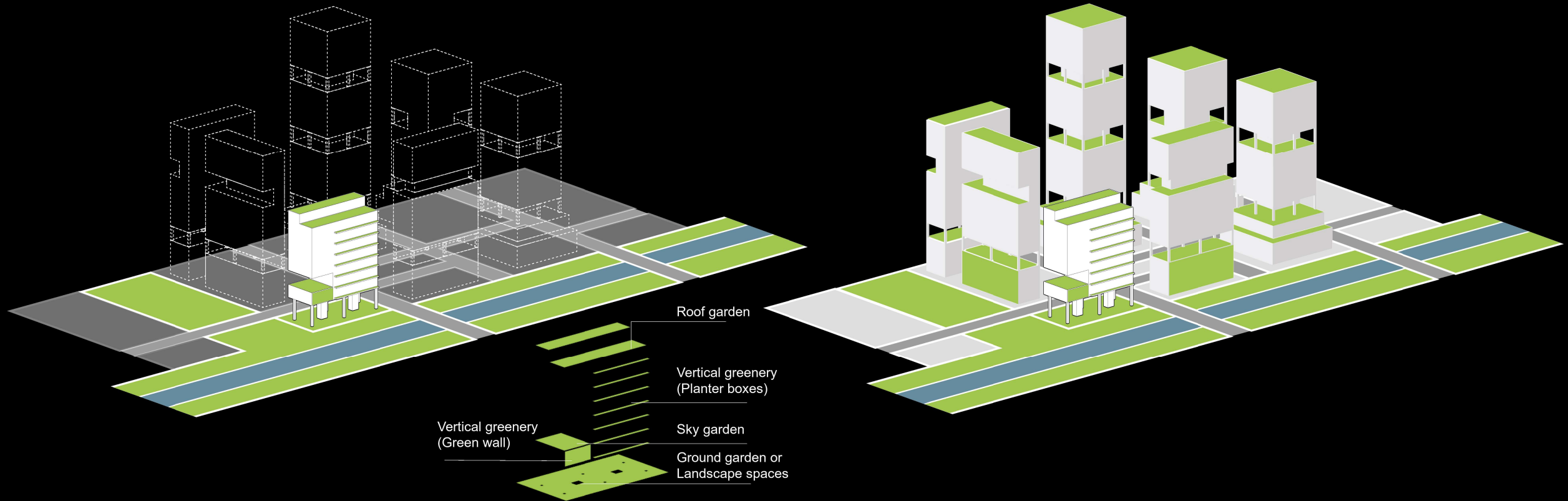
Economic Analysis of Vegetation on Residential Developments

Dense and Green Cities for a Nature – Positive Future

Performative Buildings to Districts

Dense and Green Cities (2020)

- From building scale to urban scale: urban-innovations-and-systems-solutions-approach to planning and design
- Sustainable Integrated Districts (SIDs) as a model for high-density high-liveability future cities
- Potentials of systems solutions by deploying and integrating them at the district scale
- Placed-based approaches to governance arrangements to strengthen local human capacity



Dense and Green Cities

Emerging Models of Integrated Urban Development

- SIDs aim to fully realise the potential of urban innovations and systems solutions by deploying and integrating them at the district scale.
- SIDs serve as a test bed for examining a place-based approach to governance arrangements, with a focus on strengthening local human capacity – through collaboration and mutual learning – among the diverse stakeholders



Singapore, aerial view



Zurich, Switzerland, aerial view

Dense and Green Cities for a Nature – Positive Future

Dense and Green Cities

Emerging Models of Integrated Urban Development

Research Questions

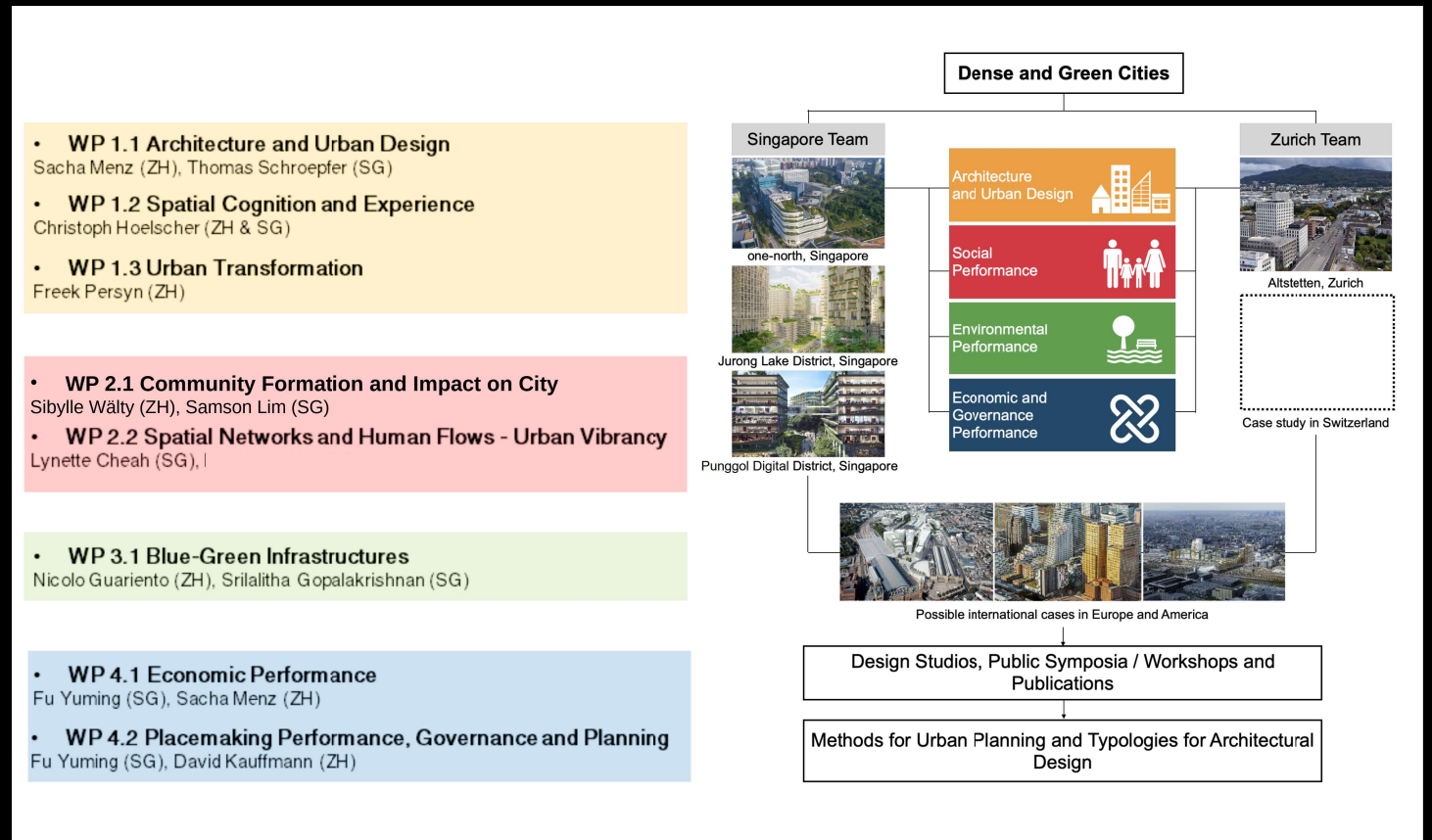
- How can the scaling up of urban innovations and systems solutions lead to resource optimisation and greater synergies at the integrated district as well as the larger city scale?
- What are effective planning guidelines and design strategies for the development of new SIDs, the transformation of existing districts into SIDs and ultimately the development of dense and green cities?
- What implications do different governance arrangements provide on SIDs? To what extent are resource optimisation and functional synergies affected by a specific socio-spatial context framed by the governance system?

Methodological Novelties

- Systems solutions approach to investigate the performance of SIDs
- Context-based research methods for cases in Singapore and Zurich
- Combination of location-based GPS data and real-world observation data
- Integration of analyses and findings toward tangible outcomes

Dense and Green Cities for a Nature – Positive Future

Research Framework



- **WP 1.1 Architecture and Urban Design**
Sacha Menz (ZH), Thomas Schroepfer (SG)
- **WP 1.2 Spatial Cognition and Experience**
Christoph Hoelscher (ZH & SG)
- **WP 1.3 Urban Transformation**
Freek Persyn (ZH)

- **WP 2.1 Community Formation and Impact on City**
Sibylle Wälty (ZH), Samson Lim (SG)
- **WP 2.2 Spatial Networks and Human Flows - Urban Vibrancy**
Lynette Cheah (SG), I

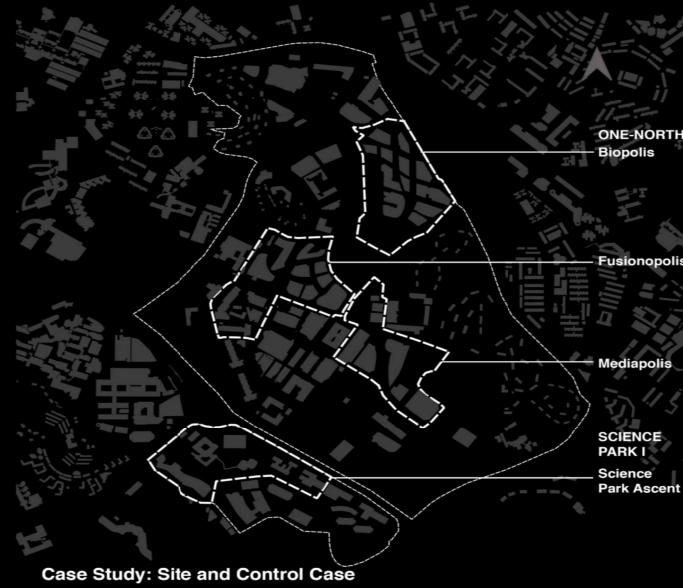
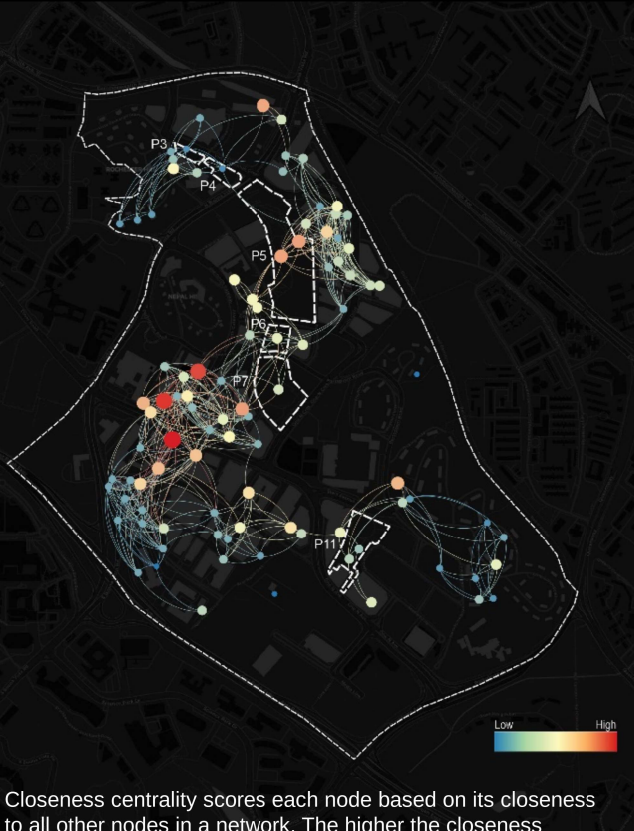
- **WP 3.1 Blue-Green Infrastructures**
Nicolo Guariento (ZH), Srilalitha Gopalakrishnan (SG)

- **WP 4.1 Economic Performance**
Fu Yuming (SG), Sacha Menz (ZH)
- **WP 4.2 Placemaking Performance, Governance and Planning**
Fu Yuming (SG), David Kauffmann (ZH)

Architecture and Urban Design

Spatial Analysis of Sustainable Integrated Districts

- Did the SID's urban form lead to greater pedestrian flows and activity than in other districts?
- What characteristics did planning and design strategies in SIDs generally share as they relate to pedestrian flows and activity, and their effect on urban vibrancy?
- Were there emerging urban forms that support greater pedestrian flows and activity?



Spatially Integrating Element

High Program Mix

Multiple Public Levels



- Spatial characteristics of integrated districts (FCL) FUTURE CITIES LABORATORY GLOBAL

Dense and Green Cities for a Nature – Positive Future

Architecture and Urban Design

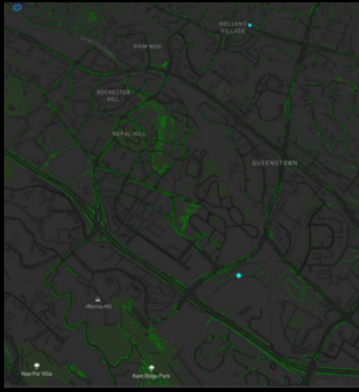
Urban Visual-Spatial Analysis

- How the visual environmental context and urban morphology affected the way people inhabited, used, and interacted in public spaces and how urban design features, elements, and experiences affected their usage patterns?

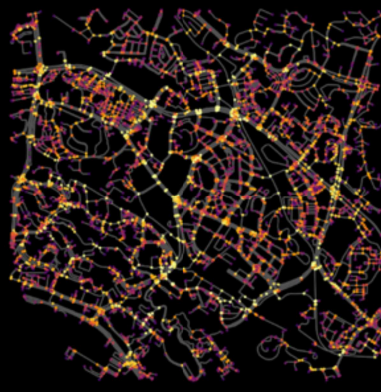
Buildings and walking network



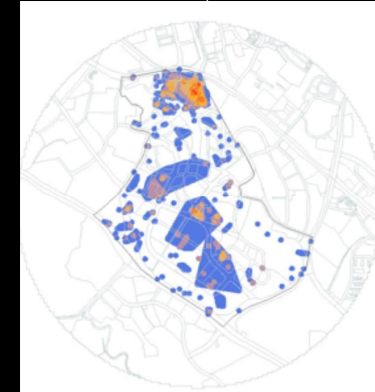
Greenery



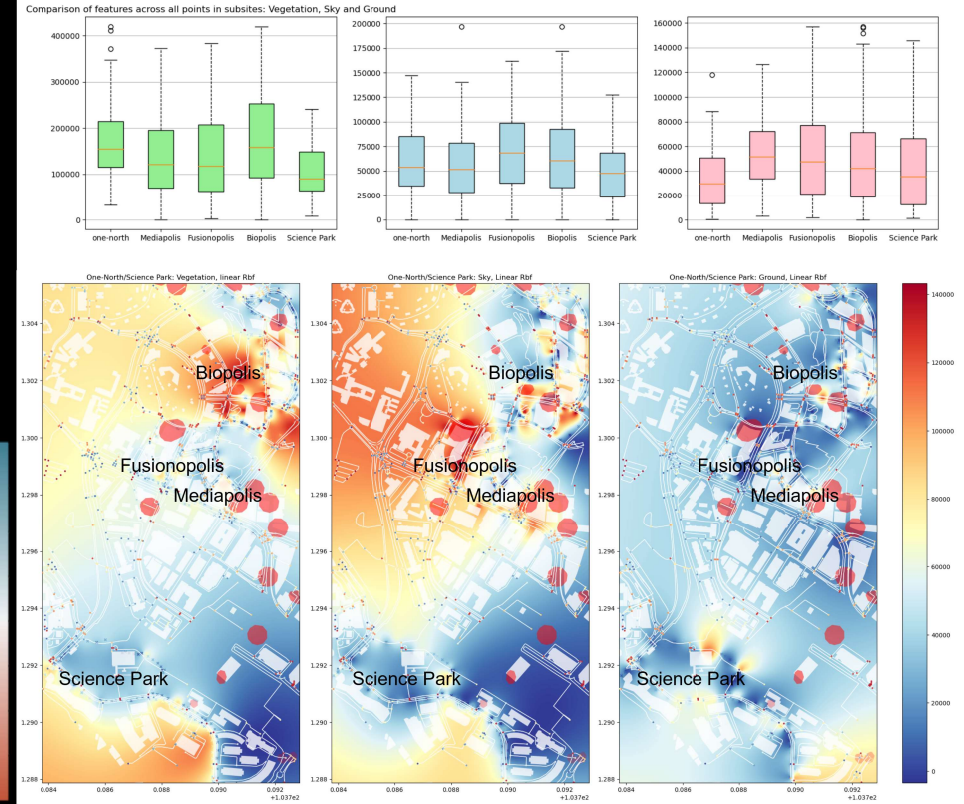
Network connectivity



Social interactivity

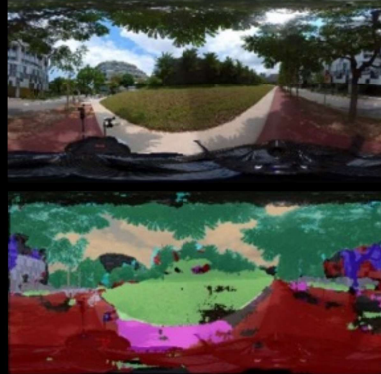


Visual analysis

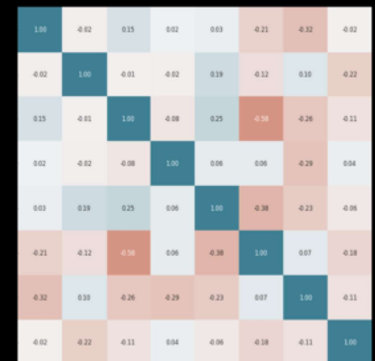


Visual analysis

Feature segmentation



Feature correlation in image sets

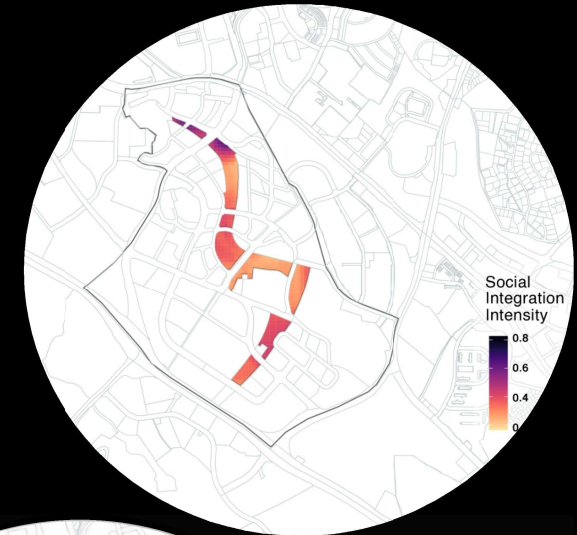
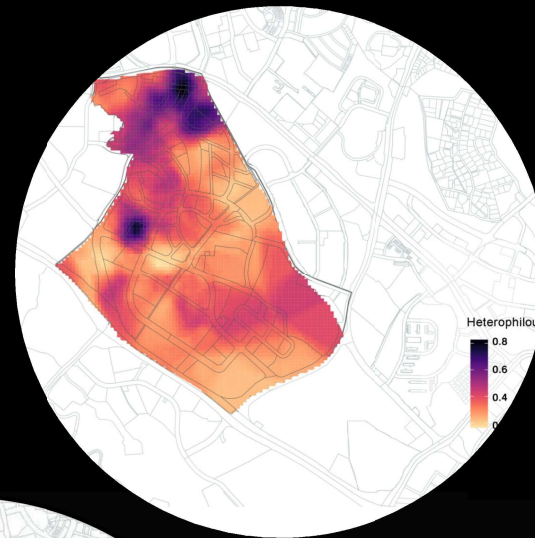
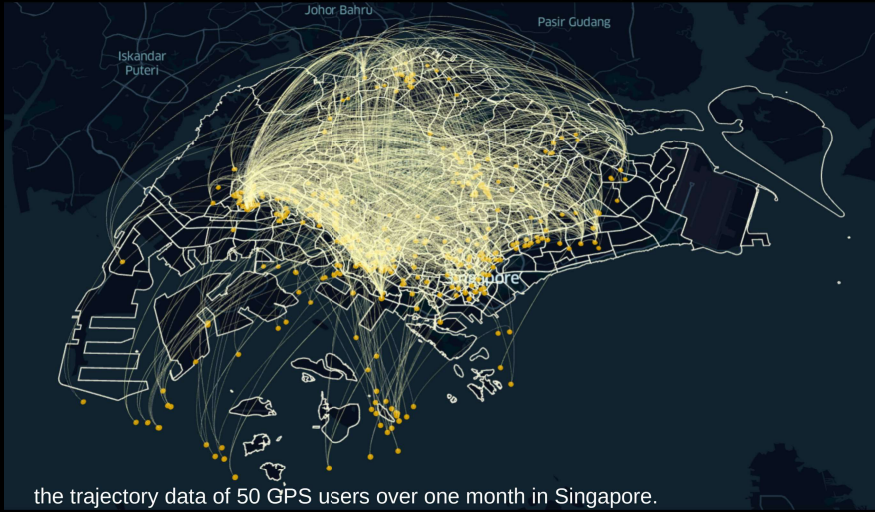


Dense and Green Cities for a Nature – Positive Future

Social Performance

Socio-spatial Integration in SIDs

- How does the spatially integrated SID promote social integration?



Source: Socio-spatial integration in innovation districts: Singapore's mixed-use experiment

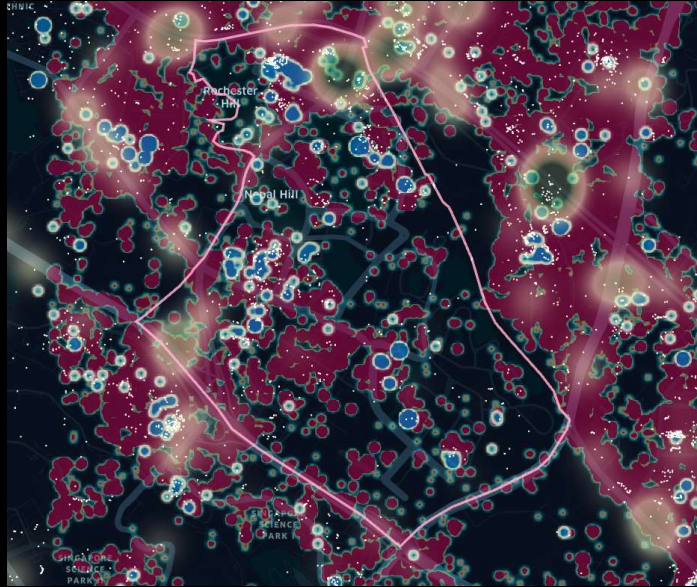
Spatial characteristics of integrated districts

- Community Activity Spaces and Interaction Opportunities

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Social Performance

Spatial Networks and Human Flows - Urban Vibrancy of SID's



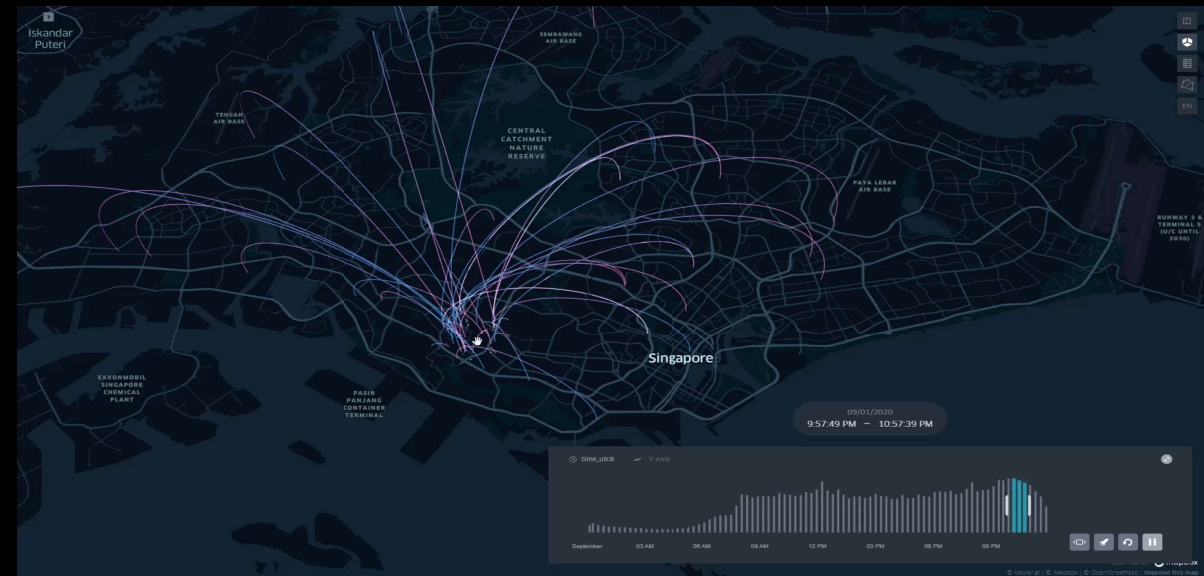
Compiled Map

- Citydata (2020.9.1-2020.9.7)
- Tweets (2018-2022)
- POI (extraction at 2021)
- Bus trips (2021.1 weekday)



one-north: Points of Interest (POI) mapping within the planning area

Observation | temporal pattern of long-distance and short-distance transitions



Dense and Green Cities for a Nature – Positive Future

Environmental Performance

Outdoor Thermal Comfort Assessment in SIDs

- Climate change and rapid urbanization worsen outdoor thermal conditions, causing thermal discomfort and heat-related mortality.
- How do SIDs contribute to outdoor thermal comfort?
- Do SIDs provide better cooling services than traditional districts in tropical climates?

Mobile survey

Image Processing

Urban Heatmapping Findings

Instrumentation

- Heat stress trackers (Kestrel 5400) measure heat stress, temperature, humidity, wind speed, and solar radiation.
- 180° fisheye lenses capture upward environments, e.g., sky, building, and tree crown.
- Smart phones with GPS tracker record GPS coordinates.
- Radiation shields and data loggers (Rotronic HL-1D) combined measure temperature and humidity at 1 m.
- Radiation shields and data loggers (Rotronic HL-1D) combined measure temperature and humidity at 0.5 m.



Instrumentation setup for parallel mobile survey

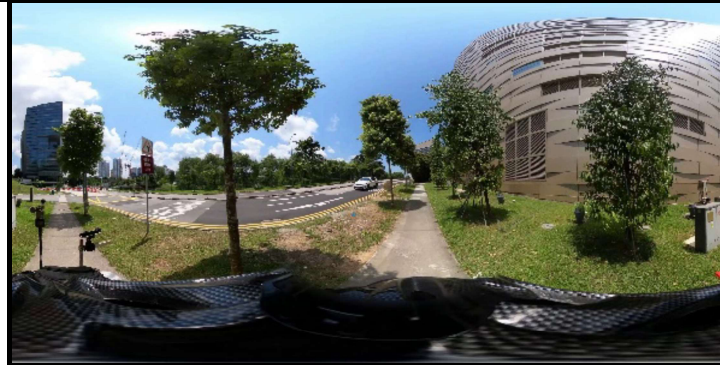
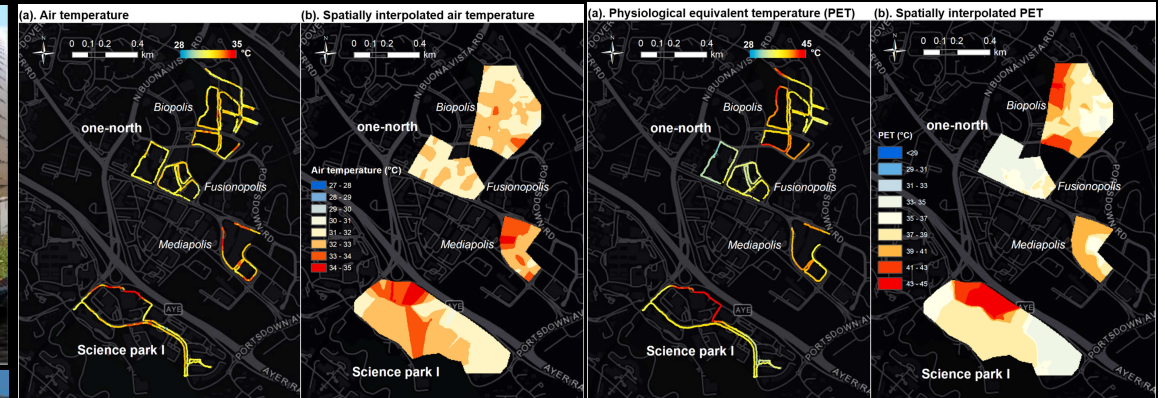


Figure. a) original panoramic street view image, b) semantically segmented image



Spatially distributed air temperature in one-north and Science park I, a) measured air temperature and b) spatially interpolated air temperature

Spatially distributed physiological equivalent temperature (PET) in one-north and Science park I, a) calculated PET and b) spatially interpolated PET

- one-north, especially in the Biopolis and Fusionopolis subsites, provided cooler air temperature than Science Park I.
- The mean temperature in one-north was 0.3°C lower.
- The percentage of hot weather (air temperature > 33°C) in one-north was 8%, compared to 24% in Science Park I.

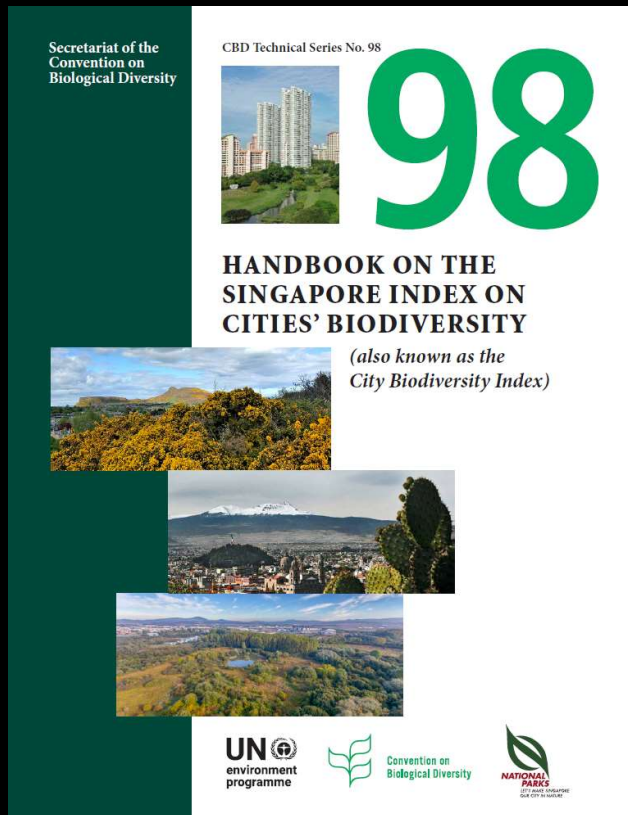
- one-north, especially the Fusionopolis subsite, provided more thermal comfort than Science Park I.
- The mean PET (a thermal comfort index) in one-north was 0.8°C lower.
- The percentage of 'very hot' thermal perception in one-north was 1%, significantly lower than 15% in Science Park I.

Ecological Performance

Urban Landscape Connectivity in SIDs

- The study investigated how Blue-Green Infrastructure (BGI) in SIDs contributes to increasing ecological connectivity and biodiversity at the district scale.
- Do the district's urban green and blue open spaces improve the overall landscape connectivity for the larger urban context?
- Do the district's urban green and blue open spaces act as key ecological connectors?

Singapore Index (SI) on Cities' Biodiversity
Self-assessment tool to benchmark biodiversity efforts within urban contexts



Urban Scale



District Scale



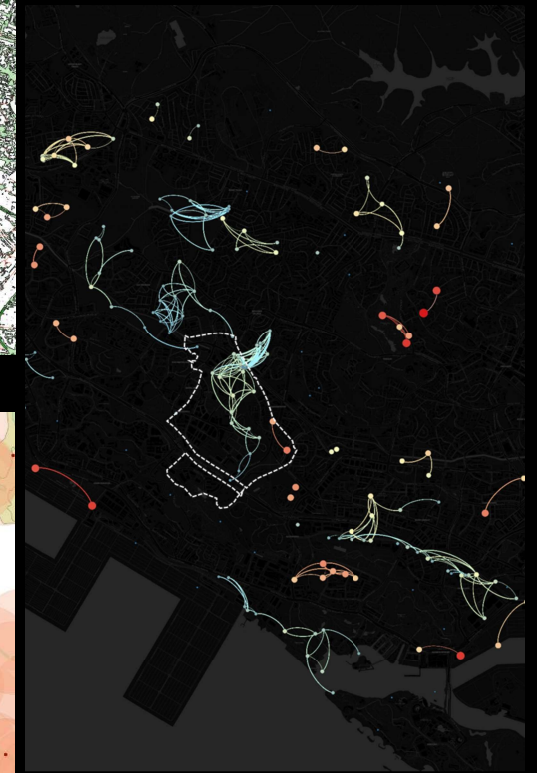
Comparison of habitat provision considering only natural and natural + managed green areas



Map indicating the proximity and accessibility of plots to parks and green spaces within a 400m radius (5-minute walking distance)



Urban Landscape Connectivity Analysis (a)
Closeness score within a 5-km radius of one-north;



Dense and Green Cities for a Nature – Positive Future

Economic Performance

Socio-economic Integration in SIDs

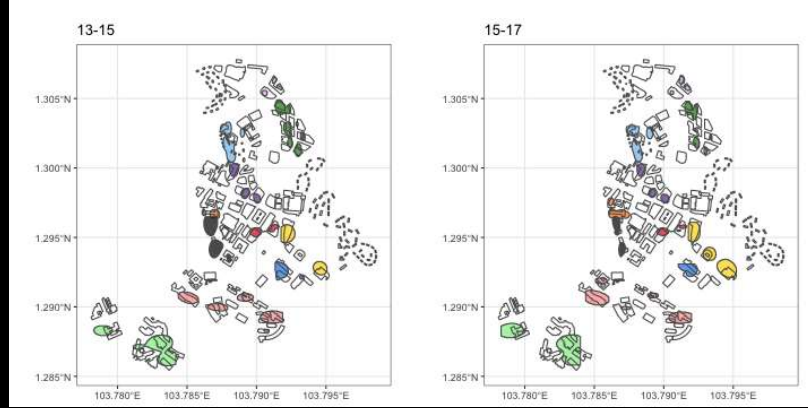
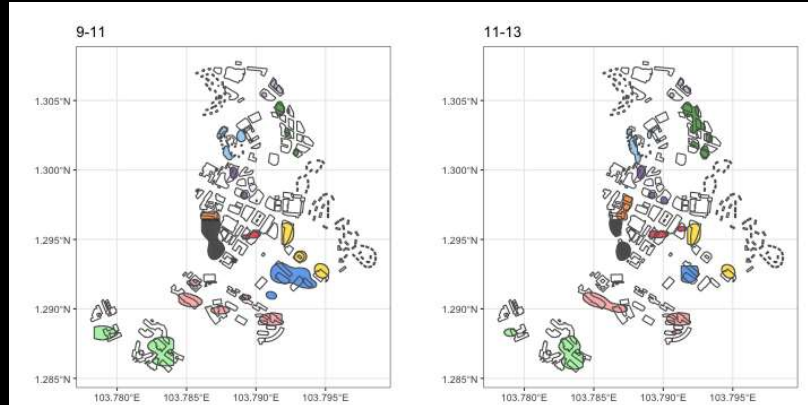
- How does the districts' public realm (or the "living room") support social interactions?
- To evaluate the economic performance of a SID compared to the control sites by examining the relationship between people's mobility and social hotspots and analysing how the demand for face-to-face interaction drives location choice



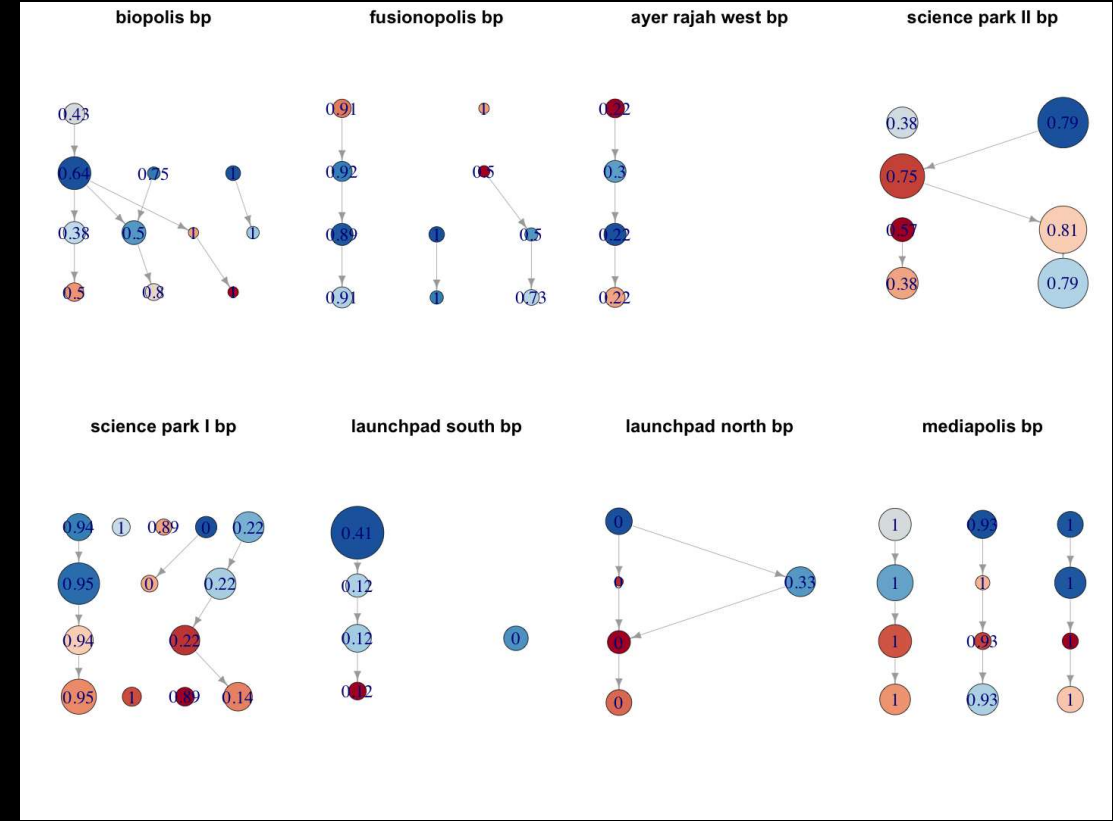
Plaza space in one-north



Urban spaces within one-north district



Spatiotemporal Hotspot Network Evolution



Subsites "living room" signatures

Dense and Green Cities for a Nature – Positive Future

Digital Tools for SIDs

Visualisation Dashboard and Analytical Tool

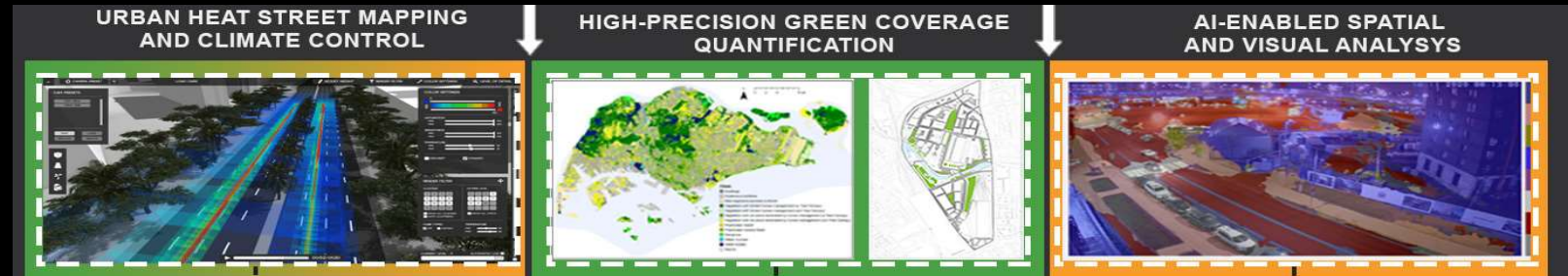
- Digital twins are used as an effective research tool for an urban scale analysis and future scenario planning



Digital twin of Sustainable integrated district one-north park



Virtual on site experience for VR, Computer vision and visual cognition analysis



Dense and Green Cities for a Nature – Positive Future

Dense and Green Cities - Team

Emerging Models of Integrated Urban Development

Dense and Green Cities Singapore



Principal Investigator
Prof. Dr **Thomas Schroepfer**
ASD, SUTD



Postdoc Researcher / Coordinator
Srilalitha Gopalakrishnan
SEC FCL



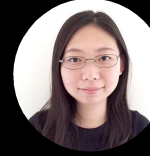
Co-Investigator
Prof. Dr **Christoph Hoelscher**
COG, ETH Zurich



Postdoc Researcher
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Science of Cities Symposium 2023

Poster presentations at the SoC Symposium 2023

Pedestrian Movement Distribution Patterns in Multilevel Urban Environments

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KEYWORDS: MULTILEVEL URBAN ENVIRONMENT, PEDESTRIAN MOBILITY, SPATIAL NETWORK ANALYSIS, URBAN DESIGN, URBAN PLANNING, VERTICAL DEVELOPMENT

BACKGROUND

As cities densify, urban planners and designers are increasingly utilizing vertical space to accommodate growing populations and limited land. Elevated and underground spaces with programmes such as mixed-use complexes, malls, and public transportation hubs, are integrated with the street network to form multilevel urban environments. Such environments offer multiple indoor and outdoor opportunities for pedestrian movement and elevating access to different levels. With the increasing need to create vibrant and livable cities, these intricate dynamics of pedestrian behaviour are unpredictable yet crucial to planning and design.

This study focuses on the pedestrian movement distribution patterns of multilevel urban environments, specifically examining the influence of the spatial configuration on the pedestrian flows, activity, and space utilisation. Using the case of Jurong Gateway subway in Singapore, it considers Spatial Network Analysis and pedestrian mapping results to model relationships between vertical indoor and outdoor spaces. In Jurong Gateway, the elevated J-Walk network allows pedestrian connectivity in an integrated multi-level street network. The pedestrian mapping was conducted in Westgate mall for one week.

METHODS

SPATIAL NETWORK ANALYSIS

- Study of network properties: Centrality measures (DF, Betweenness, etc.)
- Number of pedestrian paths that use through a node, to see how many times a space is traversed
- Identify nodes that have a higher entry point in that network
- Identify nodes that have a higher exit point in that network
- Identify nodes that have a higher connectivity
- Identify nodes that have a higher centrality
- Identify nodes that have a higher centrality

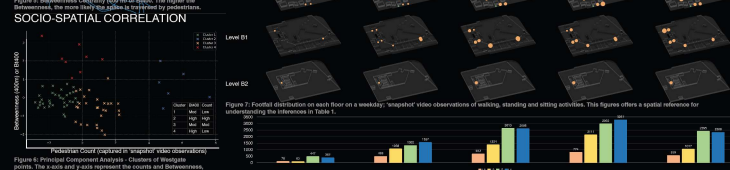
PEDESTRIAN MOBILITY MAPPING

- People Counter sensors: Record flow and volume of people at different levels
- People Counter sensors: Record flow and volume of people at different levels
- People Counter sensors: Record flow and volume of people at different levels
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- People Counter sensors: Record flow and volume of people at different levels

SOCIO-SPATIAL CORRELATION

- Correlation between spatial network and pedestrian mobility
- Use of network analysis to understand pedestrian mobility
- Use of network analysis to understand pedestrian mobility
- Use of network analysis to understand pedestrian mobility
- Use of network analysis to understand pedestrian mobility
- Use of network analysis to understand pedestrian mobility

PRELIMINARY RESULTS



DISCUSSION

Figure 7 explains that Level 2 (the J-Walk level) has the highest pedestrian volume throughout the day, amongst all the vertical levels in Westgate mall. The Spatial Network Analysis accounts for this. Thus, Level 2 is the highest connector for lateral pedestrian traffic on the weekday.

Figure 8 explains that Level 1 sometimes outperforms Level 2 as a connector for vertical pedestrian traffic. Level 1 is the highest connector for vertical traffic on the weekday.

The Principal Component Analysis and clustering results in a visually interpretable snapshot (Figure 8) of how data points relate to one another based on their Spatial Network Analysis result (BN40) and pedestrian count patterns.

CONCLUSION

The Spatial Network Analysis results cannot fully explain the pedestrian counts by linear regression. The Principal Component Analysis can better explain the correlation between the Spatial Network Analysis results and observed counts. The study can facilitate a nuanced understanding of spatial accessibility and use, when layered with qualitative and quantitative analyses of other factors, such as space functions. The methodology provides a resource-efficient, feasible way for decision-makers (the mall developers, planning agencies, etc.) to understand key gaps and potential for maintaining space use in multilevel urban environments.

NEXT STEPS

- Study of patterns of connectivity (and other factors) of spaces in order to improve predictive accuracy of Spatial Network Analysis of urban future developments.
- Processing the entire week's dataset will provide insights into patterns of space use, space functions of the mall, and accessibility.
- Practical constraints such as the limited duration of the experiment, few devices, the strenuous nature of moving data collection, and limited volunteers are limitations of the study and should be considered in the future to improve the quality of pedestrian mapping datasets.

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Acknowledgements
 We thank Jun Qing, Dan Lee, Yue Zhang, Praveen Arinamin, Daniel Wong, Han Debin, Xu Lin and Wang Xian who helped with the on-site data collection. All images, unless mentioned otherwise, are credited to Daren and Green Cities, Future Cities Lab Global, Singapore-ETH Centre.

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Mapping Urban Green Space Networks through Visual Analysis

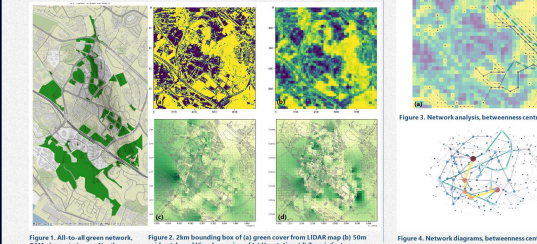
Daniel Kin Heng WONG, S GOPALAKRISHNAN, T SCHROEPPER
 URBAN GREEN SPACES, VISUAL ANALYSIS, URBAN NETWORKS

BACKGROUND

- As cities become denser, Urban Green Spaces (UGS) serve as important biodiversity habitats and social relaxation areas for city dwellers in compact urban developments.
- The continuity of their networks addresses the ecological challenges of intensified land use and fragmented habitats.
- A disparity exists between macro-scale mapping of UGS and the on-the-ground experience at a smaller scale. Recent studies integrate techniques such as satellite imagery, drone photography, and lidar imagery with crowdsourced geospatial datasets and deep learning.
- However, visually assessing and mapping the richness of UGS at human-scale remains a challenge.

METHODS

- The research uses a case study of one-north, a sustainable innovation district in Singapore. It employs urban visual analysis to map street-level urban and greenery features onto the existing green cover network.
- We overlay a visual mapping of combined vegetation and terrain features with a gradient patch model of green cover in a 2km boundary of a lidar map. A visual map is generated from the computer vision-based semantic segmentation of street-level panoramic image sets.
- We use network analysis to assess greenery patch connectivity in the resulting mapping. We filter the connectivity of neighbouring patches using a threshold of value similarity. Node and edge betweenness centrality measures are used as indicators of route corridor importance.



CONCLUSION

- Our findings provide insights into the impact of visual data on green space design and urban morphologies in dense environments. Our proposed enhanced UGS mapping offers an improved understanding of green cover from the experiential perspective, and their network structural connectivity.
- This approach empowers spatial planners and designers to adopt an urban science-driven approach for the planning of resilient, sustainable, and effective urban spaces.

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NATIONAL RESEARCH FOUNDATION, PRIME MINISTER'S OFFICE, SINGAPORE-ETH CENTRE, SUTD

Space Use Patterns through Spatial Network Analysis and thermal comfort assessment

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³Zhejiang University, College of Civil Engineering and Architecture, China

KEYWORDS: SPACE USE PATTERN, SPATIAL NETWORK ANALYSIS, THERMAL COMFORT, RESILIENT URBAN DESIGN

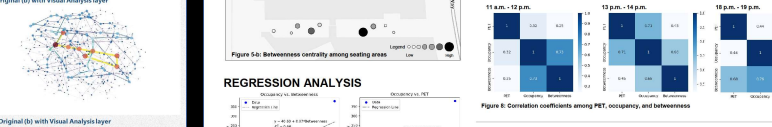
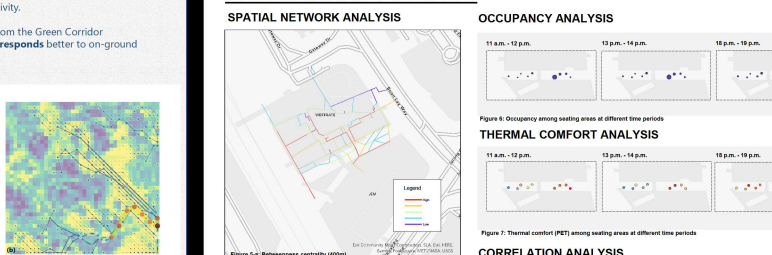
BACKGROUND

Urban vibrancy is a multifaceted concept shaped by factors like the spatial accessibility and individual comfort. Urban planners and designers increasingly adopt evidence-based approaches to enhance urban vibrancy and livability by considering elements such as spatial accessibility and thermal comfort. Considering both becomes particularly challenging in urban settings under climate change.

Our study proposed a hybrid method combining Spatial Network Analysis and thermal comfort assessment to visualize space use patterns. We carried out field surveys to gauge the thermal environment and monitor occupancy. In setting areas near Singapore's Westgate Mall, using Spatial Network Analysis, we mapped spatial accessibility, i.e., betweenness. Meanwhile, occupancy details were mapped from video footage, and the thermal comfort index, Physiological Equivalent Temperature (PET), was estimated from collected weather data. A subsequent correlation analysis was conducted among these variables. Furthermore, a probabilistic model was proposed to project occupancy with both space accessibility and thermal comfort.

Our research underscores the importance of weighing both spatial accessibility and thermal comfort in urban planning, especially in the Urban Heat Island Effect context. By integrating our findings, urban planners and designers can craft strategies for cities that are more livable, sustainable, and climate-resilient.

PRELIMINARY FINDINGS



DISCUSSION AND CONCLUSION

Our findings provide insights into the impact of visual data on green space design and urban morphologies in dense environments. Our proposed enhanced UGS mapping offers an improved understanding of green cover from the experiential perspective, and their network structural connectivity.

This approach empowers spatial planners and designers to adopt an urban science-driven approach for the planning of resilient, sustainable, and effective urban spaces.

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Poster presentations at the SoC Symposium 2023

Emergent Social Hotspots

I. Orlenko, L. Cheah, Y. Fu, T. Schroepfer

Social Dynamics, Emergent Spatial Organisation, Complexity

(FCL) FUTURE CITIES LABORATORY



BACKGROUND

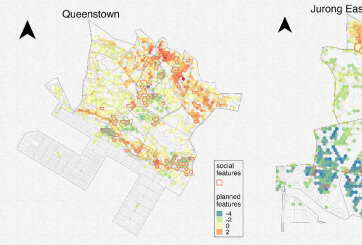
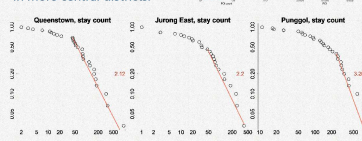
- Social vibrancy entails diverse social interactions and networks, which, in well-planned places, often sort themselves into social hotspots of various sizes according to the functionality and network centrality of the hotspots.
- Many open complex systems, such as cities, have a size distribution that can be described by a power law.

RESEARCH GAP

Few studies have sought to empirically quantify social hotspots and their emergent spatial order in urban districts. Such empirical facts are crucial for motivating and testing theories of urban vibrancy.

FINDINGS

The system of hotspots in each district has an approximate power-law order. The size dispersion of hotspots appears bigger in more central districts.

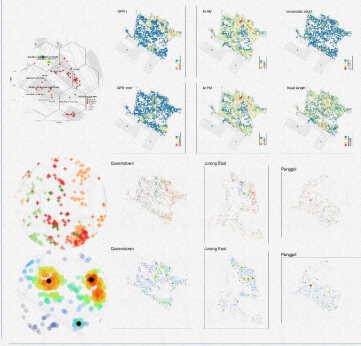


AIM

We use an urban science approach to examine the self-organization of social hotspots in the urban context of three planning areas of Singapore.

METHODS

- GPS mobile phone data, POIs -> PAM spatial clustering
- Transport infrastructure measures -> PCA



Emergent Spatial Distribution of Social Hotspots: Analysis of Three Planning Areas in Singapore

CONCLUSIONS

- Urban science seeks to identify essential phenomena at different scales that emerge from network interactions of people and businesses in complex urban systems.
- GPS data opens an avenue for applying urban science to the study of social vibrancy in urban districts.
- Our preliminary findings suggest the potential for this new avenue to uncover the influence of urban and planning context on social vibrancy phenomena.

Future applications

- Further insights into urban vibrancy can be gained by examining the scaling properties of hotspots with respect to various behaviors and attributes of their visitors, such as visit frequency, distance from home, and the mix of within-district vs. outside visitors.
- Cross-district comparison of hotspot size dispersion and scaling can reveal how social vibrancy of a district is influenced by its social, spatial, and land-use context.

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Designing for Diversity: The Impact of Visual Environment

Tongchaoran Gao, Daniel Kin Heng Wong, Prof. Thomas Schroepfer

Visual environment, Computer vision, Social integration

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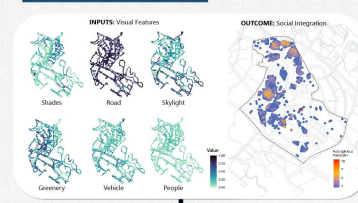
BACKGROUND

High-density urban areas can enrich lives while also inducing social withdrawal, which negatively affects cross-cultural interactions and exacerbates social segregation. Recognizing the crucial role of well-designed public spaces in fostering healthier lifestyles and social engagement, this study aims to examine how spatial features within these areas contribute to social integration. The research is centered on one-north, a sustainable innovation district in Singapore, where effective social integration is key to attracting and retaining talented workers.

RESEARCH GAP

While the visual environment is a key aspect of spatial features, its impact on social integration is not well-studied, especially at the granularity of street-level data.

FINDINGS



INPUTS	OUTPUT
Visual Features (Shades, Road, Skylight, Greenery, Vehicle, People)	Social Integration
Functional Features (Land-use Zoning, POI Diversity Data)	Social Integration
Social Features (Travel Patterns of 2,000 Users, Home Location Detection, Medium Household Income from Census Data)	Social Integration

The regression analysis reveals a significant impact of visual features on social integration, evidenced by an R2 value of 0.31. Positive contributors to social integration include shades, skylight, and greenery, while roads and vehicles negatively affect it.

CONCLUSION/S

In assessing the influence of visual environment on social integration in high-density locales, this study, centered on one-north in Singapore, utilized GeoAI techniques. It determined that aspects such as shades, skylight, and greenery enhance social integration, whereas roads and vehicles detract from it.

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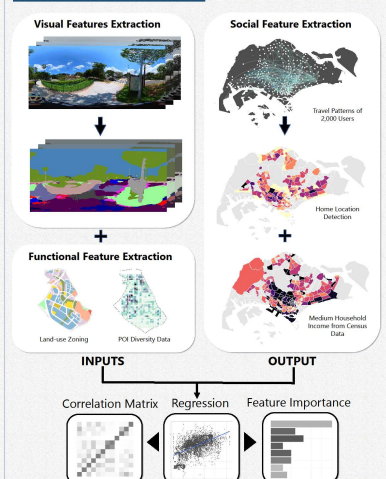
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AIM

The objective is to integrate social integration considerations into urban design by investigating the correlation between the visual environment of public spaces and the level of social integration therein.

METHODS



Employing a GeoAI methodology, the study undertakes three main steps. First, it analyzes 5,800 street view images from one-north using the SegFormer computer vision model to extract visual features. Second, it utilizes the travel patterns of 2,000 anonymous GPS users to extract social features. Third, it gleans functional features from Point of Interest (POI) data and Master Plan zoning information. These datasets are then synthesized in a regression model to assess the impact of visual environments on social integration.

<Future applications>

The methodology and findings can be adapted for evaluations in different urban settings, further refining our understanding of how visual elements contribute to the social fabric of a community.



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