# #109.

# City change; monitoring target completion of urban interventions in Stockholm

## Understanding effects of urban development projects in Stockholm 2012-2019

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## ABSTRACT

This paper analyses the alignment between urban planning targets and realized projects in Stockholm from 2012 to 2019. Employing both conformance and performance-based evaluation methods, it scrutinizes changes in street networks at both citywide and project-specific levels. The study entails a comprehensive review of planning documents, detailed configurational analyses, and an assessment of public transportation access. By examining the discrepancy between planning objectives and actual urban transformations, the research underscores the necessity for more effective monitoring techniques to achieve planning targets accurately. Notably, the analysis reveals that while municipal comprehensive plans (MCPs) articulate ambitious goals for urban development, the translation of these objectives into tangible changes in the built environment remains challenging. Despite the existence of regulatory frameworks and legal mandates, such as the MCPs and zoning plans, the paper identifies significant inconsistencies in target implementation across different projects. These disparities are attributed to various factors, including changes in political will, long timeframes and limited understanding of the complexity in the built environment. Furthermore, the research advocates for the integration of digital tools and methodologies to enhance monitoring and evaluation processes in urban planning. Overall, this study contributes to the ongoing discourse on urban development by providing valuable insights into the challenges and opportunities inherent in aligning planning targets with actual urban transformations, thereby offering recommendations for enhancing the efficacy of urban planning practices.

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KEYWORDS

Planning process, target alignment, monitoring methods, urban form, weighted space syntax analysis.

# 1 INTRODUCTION

## 1.1 Background

Urban planning and development are always acts of will but form challenging processes because they are complex, last for many years and involve multiple stakeholders. Hence, targets and preconditions for planning defined in the early stages are often subject to change in the process. The intent of this paper is to provide concrete contributions to a wider development of methodologies that can be used to monitor changes in the urban structure. Emily Talen (1996) argues that planning needs to develop its own line of evaluation research, that is sensible to the specificities that concern plans that seek to guide the future physical development of cities. This is needed in order to build knowledge on whether or not and to what degree plans are actually implemented. In this paper our work includes both conformance-based evaluation, which studies the degree to which the implementation outcomes are consistent with the planning contents, and performance-based evaluation, which focuses on if the planning implementation targets has been reached, and why, (e.g., Feitelson et al, 2017; Sharifi et al, 2014; Talen, 1996). Changes in street network configuration were analysed on citywide level and on a scale of projects including their surrounding areas, in order to study the degree of target consistency in planning documents across scales compared to how plans are realized in the built environment between 2012 and 2019.

In this paper, our main discussion concerns how Stockholm's strategic planning targets compare to implementation in zoning plans with respect to effects on and of spatial configuration. While the importance of configurational properties in cities is well established, it is not widely studied explicitly how specific projects affect their surroundings, and how configurational changes operate over time. How, if, and when local interventions contribute to overall target completion also constitutes a pervasive challenge in municipal planning practice. Therefore, this paper investigates the impacts of changes invoked by specific projects in the municipality to create a more refined understanding of what kinds of contextual effects interventions have. In the paper, the objectives of urban design and planning practice in Sweden will be briefly outlined. Next, the work will be contextualized in existing space syntax research, before going through the methods, analyses, findings, and their implications.

## 1.2 Targets in urban design and planning praxis in Sweden

According to Swedish national legislation, urban development projects must be in line with a long-term sustainable development of society[1]. However, there is no executive planning agency at the national level, and spatial planning is a municipal monopoly. Each municipality holds the statutory responsibility of updated planning of land and water use within their territories. The legal system for municipal spatial planning comprises the nonbinding municipal comprehensive plan (MCP), nonbinding programs, legally binding detailed plans, and building permits. The MCP presents targets for development regarding fundamentals of the intended land and water use within the municipality. Defining how the built environment is to be used, developed, and preserved to meet an expansion and housing needs. Ambitions are high but not much is known about how and to what extent the targets in the plans are effectively guiding practice or being implemented.

## 1.3 Monitoring change in urban design and planning praxis today

Monitoring is an important function of any target management process and exists in urban planning praxis on different aggregation levels. In Stockholm municipality in particular, target management and monitoring of urban development is outlined partly through the business performance management process and through the urban planning and design process, where the MCP plays the most important role as the document that includes key targets concerning future development of the city. A yearly follow-up procedure of urban development monitoring through the MCP has been recently implemented (Stockholms Stad, 2023). The methodology for this process is mostly qualitative, based on interviews with actors in the city's own organization reflecting the degree of compliance with the MCP in activities performed in their own operations. To some extent a quantitative approach has been applied, based on data on new constructions of housing and workplaces in projects between 2019 and 2022 monitoring a selection of targets focusing on how the urban planning process has affected the land use in the city. However, in order to strengthen the municipality in monitoring to what extent long-term targets are reached, there is a need to develop more concrete methods to consistently trace effects of urban interventions over time. This paper contributes to this challenge by developing a method that can be implemented to map changes in urban structure.

1 the Planning and Building Act (PBA) (SFS, 2010) and the Environmental Act (EA) (SFS, 1998).

## 1.4 Related Space syntax research

In relation to this work, a particular challenge of our study is comparative analysis on a broader scale that retains a perspective of both the parts and the whole of the municipality. As noted by Abshirini & Koch (2017), there is a challenge in doing street segment-per-segment over time comparison if many portions of a system are subject to change, e.g., if many streets are added, moved, or changed throughout the municipality. In many respects, this is arguably, why comparative studies tend to remain on a city or area level (e.g., Hillier et al, 2012; Kostourou & Psarra, 2017; Peponis et al, 2015; Sharifi et al, 2014), or build their arguments from specific comparisons (Lenart, 2013; Li et al, 2021; Peponis et al, 2016). There is also generally a missing link in research between what projects do in their immediate context, what they do to their surroundings, and how this relates to overall effects in the city as a whole. In line with the research discussed above, in this paper, changes in configuration are analyzed in relation to a selection of targets for urban development in Stockholm between 2012 and 2019. This way the changes in configurational properties are compared with the planning intents of the city of Stockholm to understand the level of target completion. The configurational analysis is made possible by comparing changes between two axial maps of Stockholm from 2012 and 2019 in combination with data on development projects. More specifically, the effects are compared on the level of treatment areas[2] (TA) of fifteen chosen projects with change on citywide level. Further, while Stockholm's overall strategy has been to increase street connectivity and integration and to improve access to public transportation, the differences between projects as well as how they contribute to this goal are studied. The aim is that results can inform the practice on whether changes in the city over time align with planning policy and to suggest improvements to current methodologies.

2 Treatment area covers the area of 1km walking distance through the street network in all directions from completed building project

## 2 METHODS OF INVESTIGATION

A methodology to evaluate effects of urban interventions over time in relation to targets in municipal planning documents is outlined. Effects of urban interventions have been studied from different perspectives: (1) on citywide and on project level, (2) relating to the targets in planning documents and (3) from the point of actual changes in the urban fabric. Further, we compare the change of chosen indicators in the treatment areas of the chosen projects with the changes of the same indicators on the citywide scale. This is done to demonstrate whether a particular change is part of an overall pattern or can be understood as particular to a location, and if this location is in or near a project, whether this project is likely to have caused those changes. Goal completion on the citywide and project level are intertwined since a realization of citywide targets are an aggregation of the overall goal completion in projects.

**Table 1**: Overview of the methodology

| **Methodology** | | |
|---|---|---|
| **2.1 Review of planning documents** | Analysis on citywide level, review of recurrent targets in the MCPs of Stockholm | Selection of target areas that were found to be recurrent in the MCPs of 1999, 2010 and 2018 |
| | Analysis of target alignment on project level, a review of planning documents of 15 projects | Reviewing alignment between MCP target areas and project level targets |
| **2.2 Configurational network analysis** on citywide and project treatment area (TA) level | Construction and methodological alignment of two axial maps of 2012 and 2019 | |
| | Analysing changes in integration and betweenness values between the two models | a) difference in total count of axial lines, b) difference in local, neighbourhood and global average integration c) differences in core betweenness values d) difference in total count of squares with core betweenness values. |
| | Translation of output data to grid | |
| | Definition of project treatment areas | |
| **2.3 Analysis of access to rail bound public transportation (RPT)** on citywide and project treatment area (TA) level | Analysing changes in walking distance from address points to RPT entrances | a) address points within 400-meter, b) medium distance, c) maximum distance |
| **2.4 Analysis of changes in location value** on citywide and project treatment area (TA) level | Combining results from network and RPT analysis | a) address points within 400-meter, b) medium distance to RPT, c) maximum distance to RPT and d) differences in core betweenness values e) difference in total count of squares with core betweenness values. |

## 2.1 Review of planning documents

***a. Analysis of targets on citywide level***

The projects studied in this paper were completed between 2012 and 2019, but since process timelines tend to stretch over a period of five to fifteen years, most project targets relate to citywide targets defined already in the MCP of 1999. In order to develop relevant methodologies, we decided to identify targets within target areas that were recurrent in the MCPs of 1999, 2010 and 2018 and that allowed monitoring using quantifiable configurative indicators over time. The relevant comprehensive plans were retrieved from the City of Stockholm planning administration archive and document management system. The documents were compared and recurrent targets that have been considered important over time in the development of the city were selected.

***b. Analysis of target alignment on project level***

In the period between 2012 and 2019, the city of Stockholm has been in a strong development phase. A total of 1247 new housing projects were completed, and 3732 new buildings were erected in the municipality. For this paper, fifteen projects were selected, projects as defined by the program or zooning plan documents in most cases comprising multiple housing projects and individual buildings. The selection was made based on project size, e.g., number of apartments, but also to include geographic distribution throughout the city, as further explained in section 2a.

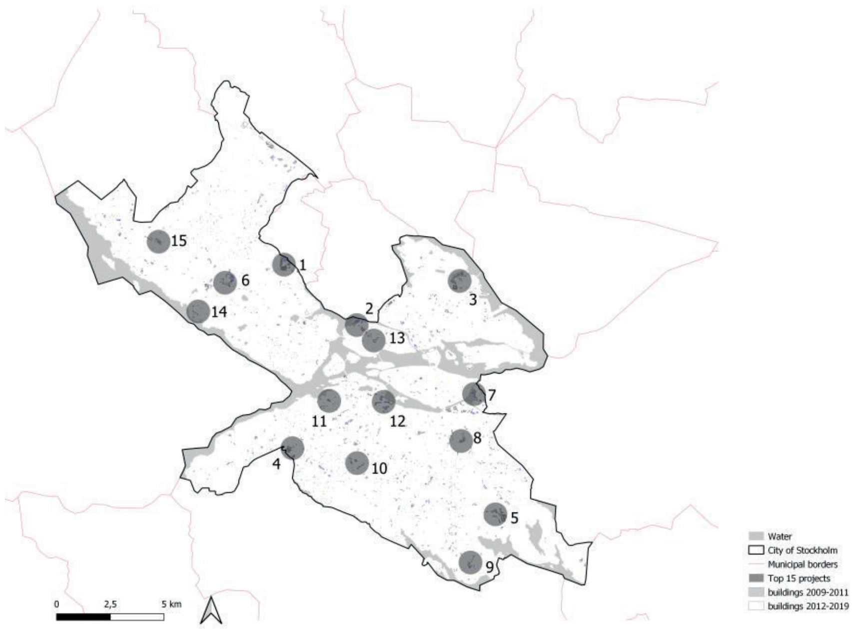



**Figure 1**: Map of the city of Stockholm including all completed projects between 2012 and 2019 and the selected projects 2012-2019: 1. Annedal, 2. Hornsbergsstrand, 3. NDS Hjorthagen, 4. Vantörsvägen, 5. Stora Sköndal, 6. Beckomberga, 7. Henriksdalshamnen, 8. Sofielundsvägen, 9. Ågestabroväg, 10. Älvsjö station, 11. Jakobdalsvägen, 12. Liljeholmskajen, 13. Kv. Snöflingan, 14. Blackebergs gård, 15. Johannelundstoppen.

A review of how two targets from the MCP of 1999, identified in study 2.1 a, had been incorporated on project level was performed[3]. Project documentation from the non-binding program stage, often considering larger urban areas and defining the broader targets for the development, and the legally binding zoning plan stage, defining the structure and programming of the projects, was analyzed.

**Table 2**: list of scores with explanations used to map target alignment in projects.

| Scores | Level of alignment with citywide targets |
|---|---|
| 2 | The target in the comprehensive plan has been fully taken care of in the program or zoning plan document |
| 1 | The target in the comprehensive plan is partially met in the program or zoning plan document |
| 0 | No targets relating to the comprehensive plan is mentioned in the program of zoning plan document |
| -1 | Compared to the target in the comprehensive plan negative output is expressed in the program or zoning plan document |

In order to visualize level of goal completion in the projects, a qualitative analysis was made of the targets according to the above table with four stages ranging from +2 to -1 indicating the level off alignment with citywide targets.

## 2.2 Configurational network analysis

In this part of the study, configurational analyses were performed using the Place Syntax Tool (Berghauser Pont et al, 2019) to investigate how projects completed between 2012 and 2019 affected changes in centrality. Analyses were made to capture change both on citywide and on project level. To do this, two comparable axial maps, a method to compare changes in the networks outside of line-by-line comparison, and a model to understand effects in the context surrounding a project were needed. Therefore, in this paper we constructed two axial maps, used a grid to analyse changes and constructed treatment areas based on walking distance to analyse contextual change.

***Analysis of changes in integration and betweenness values on two street network models of Stockholm***

The two axial maps were created based on existing versions from 2012 and 2019 that had to be improved to match our purposes since they were neither fully internally consistent, nor consistent between one-another in the way they were previously modeled. Thus, for us to measure where actual change took place, both models were given the same level of detail and were extensively

[3] Planning documents were retrieved from the city of Stockholm planning department document management system (Public 360) and from an internal cadastre service (DPmap) displaying all current zoning plans and related documents.

updated and harmonized to ensure that our analysis would capture difference in configuration and not difference in e.g. modeling or representation as may be the risk if using RCL or OSM datasets. [4]

A first control of change was made to map development of road infrastructures, following earlier evaluation research by Li et al (2021), change in number of axial lines was measured. Total number of axial lines in the 2012 network was subtracted from the lines in the 2019 network on citywide and on project TA level.

Then a series of configurational analyses were performed using both axial maps to capture changes in integration and betweenness properties. Both measures were found to be relevant to measuring completion of the targets identified in study 1. Network integration can broadly describe the potential for a place as a destination at local, neighborhood or city scale depending on the radius used in the analysis. Angular betweenness analysis on the other hand describes the potential for a place as a transit at neighborhood or city scale depending on the radius used. The axial maps were used in the analysis to ensure comparability of values and results but for the betweenness analysis, they were transformed to segment maps, since analyzing betweenness is problematic on axial lines. For a complete list of the configurative network analyses performed, see appendix table 10.

**Configurational analysis translated into 250x250 m grids**

Since across time comparison on the segment line level does not account for added, removed or remodeled segment lines, results from the configurational analysis were translated to a grid of 250x250 meter squares, which we draw from one of the standards used for mapping socio-economic data at its most detailed level (e.g., Ismail et al, 2020). It is recognized that for a strictly configurational analysis other ways to make data comparable might work better, for example by translating it into address points or areas defined by distributions of network properties (e.g., Araldi & Fusco, 2019; Diniz et al, 2023; Hamilton & Rae, 2018) but we consider future comparability to demographic data to outweigh such concerns in our case. To transfer analysis results into squares, axial/segment lines were translated into points (point every 20m along every line) that were given the attributes of each respective line. Next, values of points overlapping every 250x250 m square were transferred to the square polygons by joining summary of attributes by location. For

4 Orthophotos from 2012 and 2019 where used to compare differences between the two datasets. Additionally, data on new buildings was retrieved from the city of Stockholm and divided in two layers in the model depending on the date of completion. Buildings completed by 2011 and by 2019. Data on the waterbodies in Stockholm, topography and a street segment map from 2018 were added for an additional control of the axial maps, to compare, and check if it seemed relevant to add or remove more details and to make both maps identical for the period until 2012.

integration, mean values were used since integration is a distributive property and for betweenness, maximum values were used instead to capture the changes in structural properties in the city.

**Definition of project treatment areas**

To measure the impact of the 15 individual projects[5] (figure 2) on their surroundings, project treatment areas (TA) were created consisting of a number of 250x250 squares within a defined walking distance to all projects. The treatment areas were then used in a difference-in-difference analysis, comparing changes in the treatment areas to changes in the municipality as a whole considered as control area, a method used to evaluate change, e.g., in Ismail & Wilhelmsson (2024).

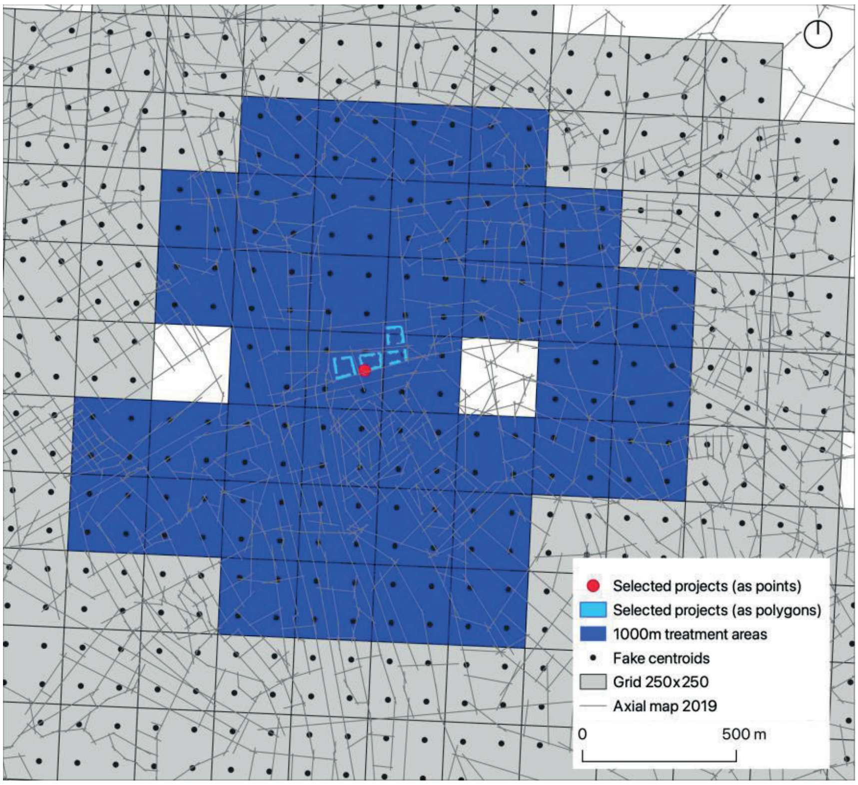



**Figure 2**: The construction of treatment areas (TA) based on fake centroids within 1000m walking distance to the projects.

The TAs were created in the following way: First, a buffer area of 1000m walking distance, measured through the street network, was created. To increase the resolution, four" fake centroids" were generated for each 250x250 m square as if each square was divided in to four quadrants. The fake

5 The 15 projects were represented by 20 points, since a group of points defined some of the larger projects.

centroids were then used as origins in an attraction distance analysis[6] and any fake centroid within 1000m walking distance to the project defined the treatment area. Second, the buffer areas were transferred back to the to the 250x250m squares, in the following way: A square was included in the TA if it contained two or more centroids within 1000m waking distance to the building project.

## 2.3 Access to rail bound public transportation (RPT) and improved location value

Using PST an attraction distance analysis from address points to rail bound station entrances was conducted for both years, on a citywide level, as well as for the selected projects. The result shows changes in how far each address point is from RPT entrances and can be interpreted as an expression of accessibility.

To perform the analysis, the axial maps from 2012 and 2019 were used together with data on RPT stations from both years. A layer of all address points in Stockholm 2018 was then cropped to match the other datasets using layers of buildings constructed before and after 2012.Then address points for all 15 TAs were created for both years to enable the analysis of change on project level and the difference-in-difference analysis. In this paper, reflecting the target in the MCP of 1999 to nudge people towards increased use of public transportation, we have chosen to use 400 m walking distance to RPT as a cut of in our analyses. This indicator was based on research that has found that 1) 400- and 800-meters walking distance is commonly used in the practice, representing approximately 5 and 10 min of walk (De Vos et al, 2022; Kaszczyszyn & Sypion-Dutkowska, 2019). 2) Research by Zhao et al (2003) that has shown that the willingness to walk to destinations decreases when the distance exceeds 580 m and that the likelihood that a person will walk to transit decreases by 50% for every additional 500 m (Loutzenheiser, 1997). Two further measures were also added to indicate a change in accessibility: the average and maximum walking distance to RPT.

## 2.4 Analysis of changes in location value

Finally, to map changes in “location value” a combination of results from the foreground network analysis and the access to RPT was used, both measures indicating degree of access to the city center. Previous studies also point out that good access to RTP has an effect on property prices, RPT stations being heavy investment and considered permanent structures in the city (e.g., Dubé et al, 2013; Jayantha et al, 2015; Laakso, 1992).

[6] Attraction distance analysis measures the actual walking distance from the origins (fake centroids) to the destinations (building polygons in our case) through the street network.

# 3 RESULTS

## 3.1 Review of targets in the planning documents

**Analysis on citywide level**

The three different MCPs[7] vary in size and precision, and although they serve to define targets for urban development of the same city, there is no direct consistency in their disposition. The following target areas, on decreasing segregation and improving access to public transportation, were found to be recurrent in all three documents, guiding urban planning in Stockholm in the past two decades

**Target area 1, decreasing segregation and increasing connectivity in the city**

- *MCP1999 (page 18) "Stockholm is growing and changing, Social dynamics and residential segregation, aim for changes in the urban structure to decrease segregation".*
- *MCP 2010 (page 41) "Connect the city districts"*
- *MCP 2018 (page 22)" A cohesive city"*

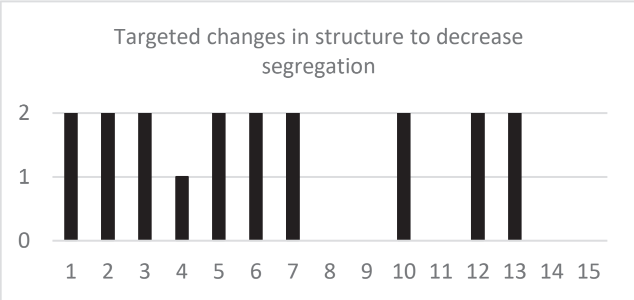
***Target area 2, access to public transportation***

- *MCP of 1999, two targets were chosen (page 5). a) "Develop the strong sides of Stockholm, well-built neighborhoods with an efficient infrastructure, Build in locations with good public transport" and (page 18) b) "Social dynamics and residential segregation. Improved accessibility and shorter journey times to the city center, improved location value".*
- *MCP 2010 (page 20-21) "A modern transport system and sustainable travel"*
- *MCP 2018 (22 and 40) "Public transport that brings the city together"*

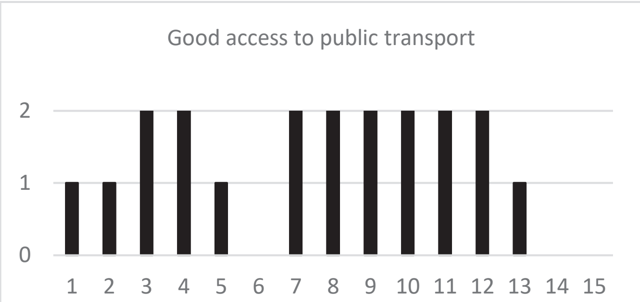
***Analysis of target alignment on project level***

The process reviewing the project documentation was time-consuming and for some projects, not all relevant documents were found. In the review, all projects were found to have targets relating to the MCP of 1999, either on program- or on zoning plan level, and only three projects had references to targets from MCP 2010. In the following analysis, the focus is on alignment with the targets in MCP 1999.

7 MCP 1999 "ÖP99"Stockholm, C. o. (1999) *ÖP99.* https://sv.wikipedia.org/wiki/%C3%96versiktsplan_1999: Stockholms stad., MCP 2010 "The walkable city", Stockholms, s. (2010) *Promenadstaden översiktsplan för Stockholm.* Stockholm: MCP 2018 "ÖP 2018" Stockholm, C. o. (2018) *ÖP 2018.* https://vaxer.stockholm/siteassets/stockholm-vaxer/tema/oversiktsplan-for-stockholm/english_stockholm_city_plan.pdf: Stockholm.

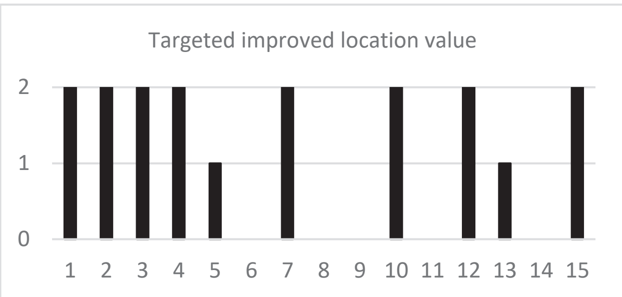



**Target area 1** in the MCP of 1999 is aiming at changing the structure of the urban environment to reduce segregation. In the planning documents, ten out of fifteen projects had targets relating to this target although one of them, 4. Vantörsvägen, with a slightly lower ambition.




**Target area 2** comprised two different targets in the MCP plan of 1999:

**a,** the first target in the MCP of 1999 addressing good access to public transportation was interpreted to indicate if the location of the project had been *chosen in areas with existing good public transportation infrastructures*. Three of the projects were deemed to be located in areas with bad public transportation infrastructures and four of them were judged to be located a bit too far from existing infrastructures. Only eight projects were thought to be within an acceptable walking distance from existing public transportation.




**b,** the second target on "*Improved accessibility and shorter journey times to the city center"* in the MCP of 1999 was interpreted to focus on the changes achieved in the project concerning improved location value, reducing travel time, making it easier for people in Stockholm to access the inner city. Fulfillment of this target was analyzed based on if the texts in the project documentation mentioned *an intent to improve access to public transportation or not*. Out of the 15 projects, eight were judged to be fully in line with this ambition and two partially, whereas five lacked the ambition to fulfill this target.

## 3.2 Configurational network analysis

### Targets on decreased segregation

To map changes relating to decreased segregation, target area 1 from the MCP, four main indicators in the street network were selected and analyzed on citywide level and on the level of project TA´s. **a)** the difference in total number of axial lines. **b)** the change in average integration (network integration, 6, 16 and 50 steps). **c)** the change in core betweenness values. **d)** the difference in total number of 250x250 squares with values representing the foreground network (angular betweenness, 5km radius).

a) The *difference in total axial lines* within the municipality between 2012 and 2019 was 494, indicating that most new projects used existing road infrastructure or were developed in a way that added only sparsely to existing structures. To understand changes on project level the same approach was taken. Segments in the axial maps of 2012 and 2019 within the defined treatment areas were isolated to calculate the change in numbers of axial lines. As displayed in the table below no big changes were detected. Project TAs 5. Stora Sköndal, 2. Hornsbergsstrand and 1. Annedal has seen the largest rise in numbers and 8. Sofielundsvägen no change at all.

**Table 3.** Change in number of axial lines between the axial maps from 2012 and 2019 compared with project targets on decreased segregation.

| Project | lines in 2012 | lines in 2019 | Diff | |
|---|---|---|---|---|
| **Citywide** | **31 725** | **32 219** | **494** | |
| **1. Annedal** | **125** | **158** | **33** | |
| **2. Hornsbergsstrand** | **608** | **636** | **28** | |
| 3. NDS Hjorthagen | 136 | 148 | 12 | |
| 4. Vantörsvägen | 442 | 454 | 12 | |
| **5. Stora Sköndal** | **461** | **511** | **50** | |
| 6. Beckomberga | 657 | 662 | 5 | |
| 7. Henriksdalshamnen | 253 | 276 | 23 | |
| **8. Sofielundsvägen** | **610** | **610** | **0** | |
| 9. Ågestabroväg | 568 | 584 | 16 | |
| 10. Älvsjö station | 437 | 447 | 10 | |
| 11. Jakobdalsvägen | 434 | 437 | 3 | |
| 12. Liljeholmskajen | 315 | 338 | 23 | |
| 13. Kv. Snöflingan | | | | |
| 14. Blackebergs gård | 240 | 248 | 8 | |
| 15. Johannelundstoppen | 774 | 788 | 14 | |
| **Project target alignment with citywide targets to decrease segregation** | **Negative** | **No** | **Some** | **Full** |

b) The second indicator used is *the difference in average integration values*. Results show that citywide values have increased on all scales over time in Stockholm, although to a very low extent. While of interest, this primarily provides a baseline for understanding what the specific projects do. When comparing project TA performance to the overall changes in Stockholm the following results were derived deducting the level of change on citywide level from the values in every treatment area.

**Table 4**: Changes integration values in project treatment areas between the axial maps from 2012 and 2019 compared with project targets on decreased segregation.

| **Difference in 2012-2019** | **NIs6_sc_dif** | **NIs16_sc_dif** | **NIs50_sc_dif** |
|---|---|---|---|
| **City Wide avdrager integration** | 0,001842218 | 0,002303525 | 0,000615649 |
| 1. Annedal | 0,012505608 | -0,002564395 | -0,000659127 |
| 2. Hornsbergsstrand | 0,004157782 | 0,001036475 | -0,001695649 |
| **3. NDS Hjorthagen** | **0,005241115** | **0,049363141** | **0,014967684** |
| **4. Vantörsvägen** | **0,000503935** | ***-0,009841987*** | ***-0,004923341*** |
| **5. Stora Sköndal** | ***-0,002459865*** | ***-0,001185878*** | ***-0,001203884*** |
| **6. Beckomberga** | ***-0,001002218*** | ***-0,000263525*** | ***-0,001995649*** |
| 7. Henriksdalshamnen | 0,021357782 | 0,005746475 | 0,002584351 |
| 8. Sofielundsvägen | -0,000692218 | -0,004578525 | -0,003340649 |
| 9. Ågestabroväg | -0,000423614 | 0,001859265 | -0,003406347 |
| 10. Älvsjö station | 0,004314032 | 0,001883975 | 0,000290601 |
| **11. Jakobdalsvägen** | ***-0,000497391*** | ***-0,000096629*** | **0,000591247** |
| 12. Liljeholmskajen | 0,01094039 | 0,00556604 | 0,003427829 |
| 13. Kv. Snöflingan | | | |
| 14. Blackebergs gård | 0,0031065 | 0,002773398 | -0,000102829 |
| 15. Johannelundstoppen | 0,000631466 | -0,000619315 | -0,003563018 |

| **Project target alignment with citywide targets to decrease segregation** | **Negative** | **No** | **Some** | **Full** |
|---|---|---|---|---|

*Negative numbers* show that the treatment area performed worse than the city level and positive numbers show that they performed better. When overlaid with the targeted performance in the projects the table reveals a pattern of target completion to decrease segregation. This analysis contains values on local level integration (NIs6) but our interest is primarily on neighborhood and global level since the target to decrease segregation is mostly achieved by connecting an area to its surrounding cityscapes. The most prominent positive change on neighborhood level was in 3.NDS Hjorthagen, while the worst performance was detected in 4. Vantörsvägen regardless the aim that the project to some extent was intended to decrease segregation.  Among the projects with targets to decrease segregation in the networks, 1. Annedal, 5. Stora Sköndal, 6. Beckomberga failed.

Visualized, in the 250x250 grid on citywide level (figure 3-5), a pattern of change can be observed making it possible to verify the changes in the tables but also to identify changes in geographies outside of the treatment areas. This was done for all integration values, from NI 6 to NI 50. Results indicate that changes in integration appear not only in and around the treatment areas but also in areas with no or very limited intervention.

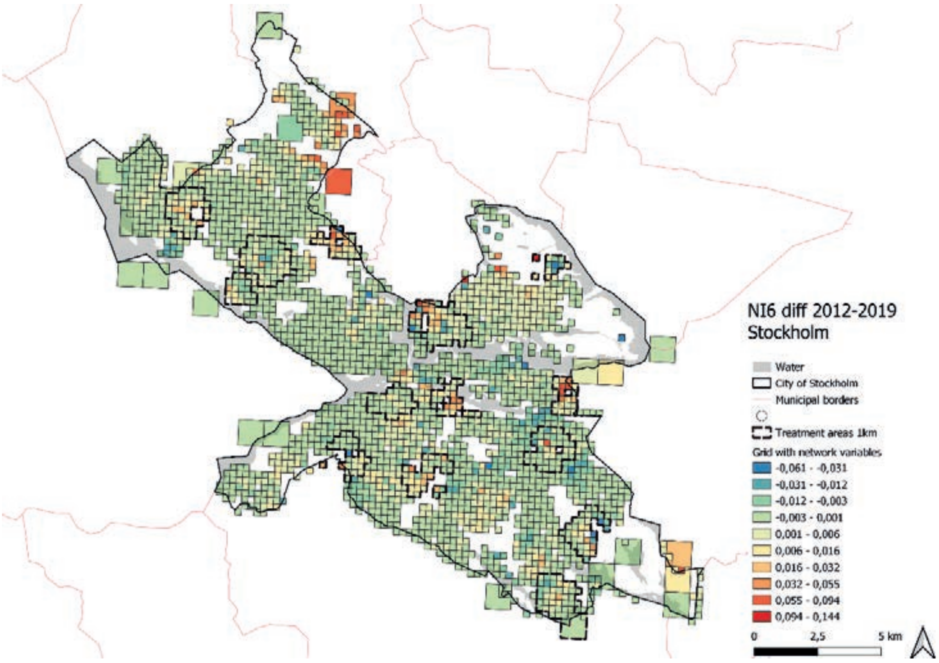



**Figure 3**: differences in average local integration (NI s6) in squares 250x250 m, due to interventions in the urban fabric 2012-2019 in the City of Stockholm.

*Average local integration* differences show positive trends in the treatment areas of 1. Annedal, 7. Henriksdalshamnen and 12. Liljeholmskajen, especially in the squares directly overlapping the construction sites. Whereas the interventions in 4. Vantörsvägen, 5. Stora Sköndal and 6. Beckomberga seems to reduce local integration.

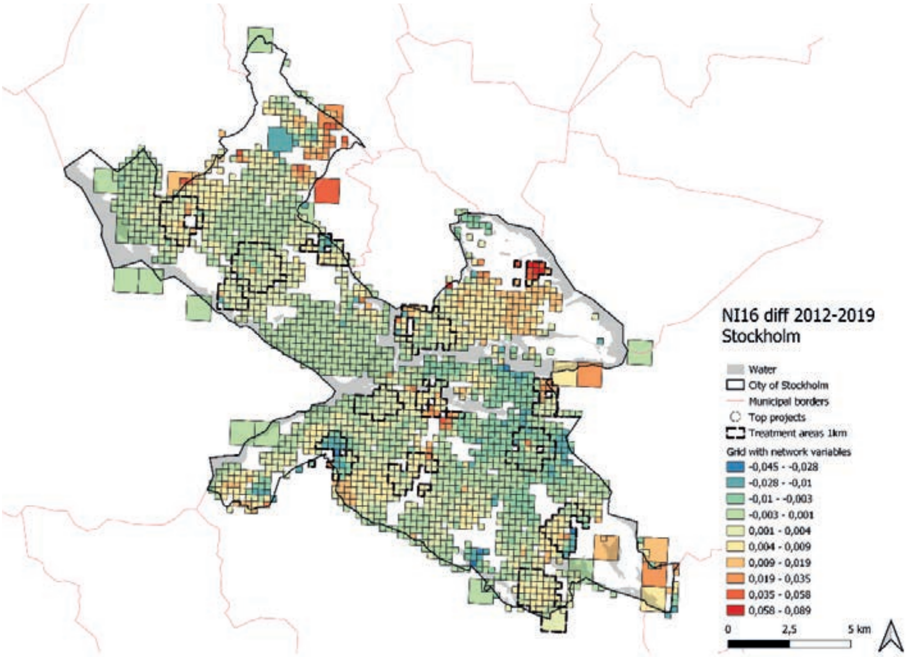



**Figure 4**: differences in average neighborhood integration (NI s16) in 250x250 m squares, due to interventions in the urban fabric 2012-2019 in the City of Stockholm.

*Average neighborhood integration* indicates a positive trend in the treatment areas of 3.NDS Hjorthagen, 7. Henriksdalshamnen and 12. Liljeholmskajen projects whereas the 1. Annedal, 4. Vantörsvägen, 5. Stora Sköndal and 8. Sofielundsvägen projects reveal a negative trend.

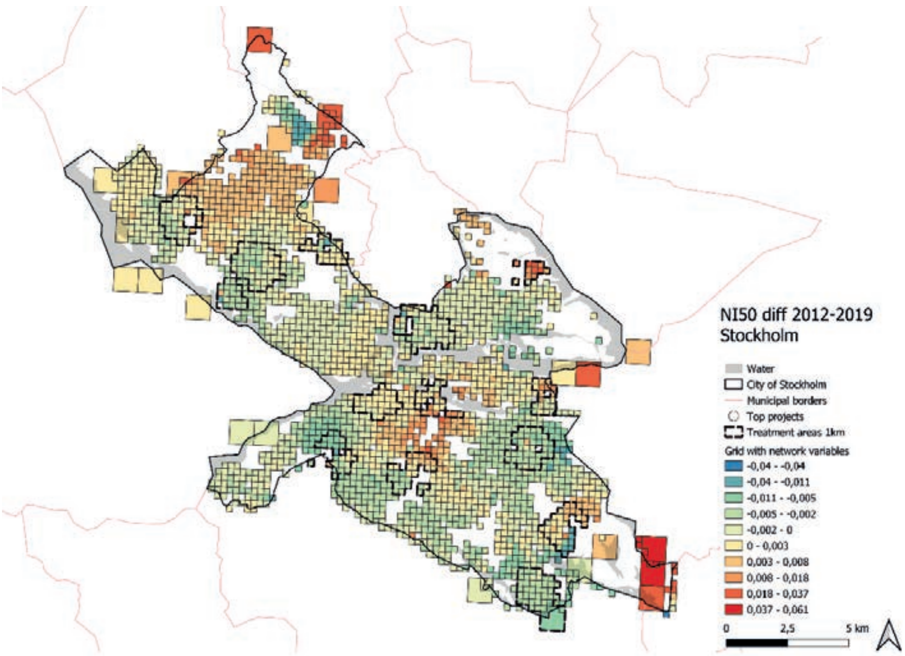



**Figure 5**: differences in average global integration (NI s50) in squares 250x250 m, due to interventions in the urban fabric 2012-2019 in the City of Stockholm.

*Average global integration* indicates increased integration in the TAs of 3. NDS Hjorthagen and 7. Henriksdalshamnen. Projects TAs 4. Vantörsvägen and 8. Sofielundsvägen show signs of decreased integration. In 5. Stora Sköndal, integration has decreased in the treatment area but not directly in the area of the intervention.

c) *Analysis of core betweenness network/foreground network.* As demonstrated by Hillier et al (2012), one important difference between networks is the distribution of integration core and foreground network, and as further studied by Abshirini & Koch (2017) and Shpuza (2013), such changes can be compared over time. However, *distribution* implies not only how many lines or segments are included as in Hillier, Yang, and Turner's analytical model, but how these are geographically distributed throughout the city. This also ties to how societal factors are most strongly related to *relative* rather than *absolute* configurational values. Based on this reasoning combined with Stockholm's goal to make the city more interconnected, *we have used the betweenness analysis to identify the foreground network*, and study if and how there are identifiable changes in how it reaches different parts of the city.

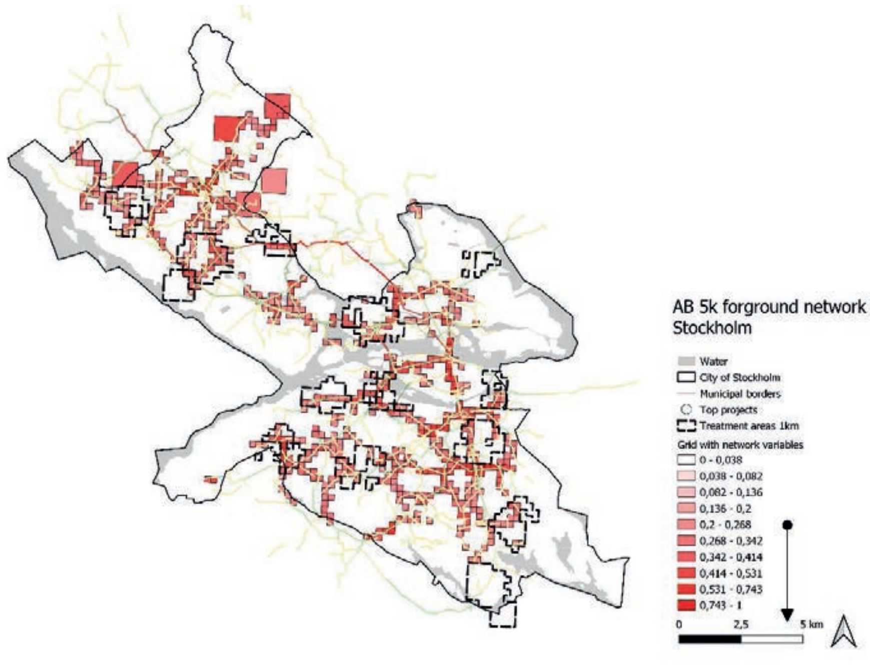



**Figure 6**: The foreground network in 2012, showing top 80% of global betweenness values (AB5k) in squares 250x250 m and segment map.

The *angular betweenness analyses at 5 kilometers*, year 2012 and 2019, was used to capture values that affects the citywide scale. The foreground network was filtered out, by selecting top 80% of the betweenness values in the city for both years individually, following the study of Shpuza (2013), who concluded that the top 80% betweenness values represents the foreground network that has the strongest impact on the overall street network. A comparison of segment map and grid data was used to confirm the relevance of using the same cutoff value for the grid (Fig 6). Next, the value for each year was calculated, and then the difference between the years was measured by subtracting the value for 2012 from 2019. The result shows the average change in core betweenness values in Stockholm. The process was then repeated using data retrieved from all 15-treatment areas to understand their individual performance.

The following changes were detected; on citywide level, a slight decrease in overall core network values was identified between 2012 and 2019. The performance of the 15 projects was compared to the change on citywide level by subtracting the citywide value from core difference values in every treatment area.

**Table 5**: Changes in the top 80% betweenness values in project treatment areas between the axial maps from 2012 and 2019 compared with project targets on decreased segregation.

| **Difference in 2012-2019** | **AB5k_core_dif** |
|---|---|
| Citywide level | -0,006112163 |
| Project performance compared to citywide measures. | |
| 1. Annedal | 0,03077883 |
| 2. Hornsbergsstrand | 0,017612163 |
| **3. NDS Hjorthagen** | **0,06485502** |
| **4. Vantörsvägen** | **-0,122046567** |
| **5. Stora Sköndal** | **0,051627037** |
| 6. Beckomberga | 0,016561626 |
| 7. Henriksdalshamnen | 0,018958317 |
| 8. Sofielundsvägen | 0,01765383 |
| 9. Ågestabroväg | 0,017008644 |
| **10. Älvsjö station** | **0,06377883** |
| 11. Jakobdalsvägen | 0,010112163 |
| 12. Liljeholmskajen | 0,007424663 |
| 13. Kv. Snöflingan | |
| 14. Blackebergs gård | 0,009969306 |
| 15. Johannelundstoppen | 0,005075126 |

All project but one had rising values indicating a positive impact regardless of if they were aiming at decreasing segregation or not. Only the no 4. Vantörsvägen project stands out with a relatively high negative number. Three projects with targeted positive change in segregation also stands out with comparatively higher values; 3. NDS Hjorthagen, 5. Stora Sköndal and 10. Älvsjö station.

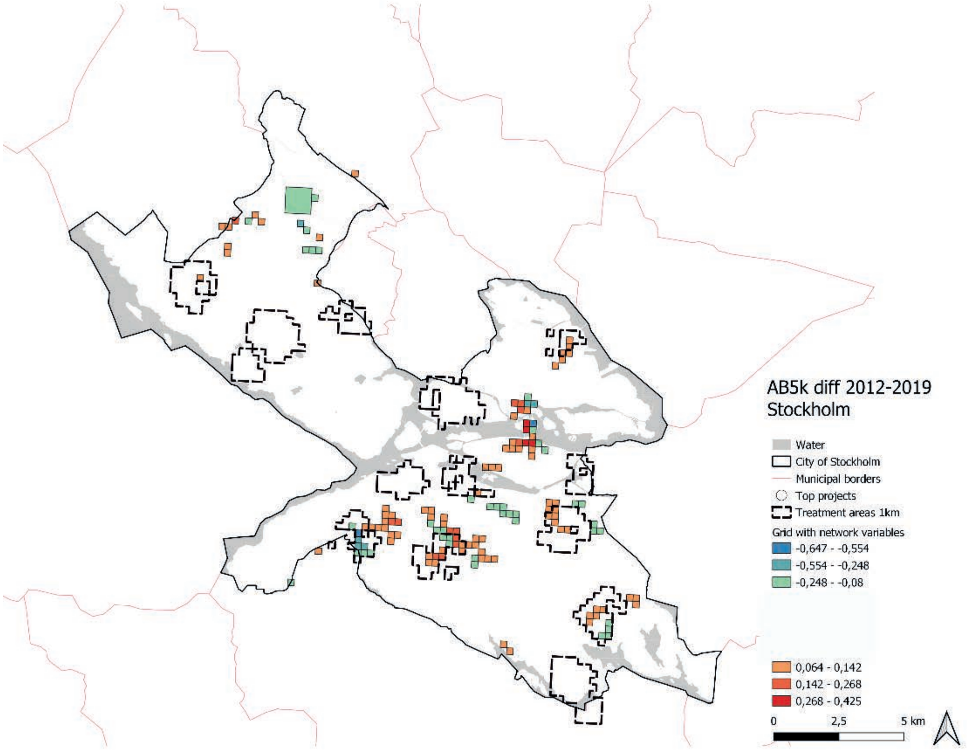



**Figure 7**: Top and bottom changes in global betweenness values (AB5k) 2012-2019, squares 250x250 m in relationship to the 15 treatment areas.

Looking only at changes in maximum and minimum betweenness values between the years and overlaying the map with the treatment areas, the pattern is confirmed but the map also reveals another pattern of change with a rise in betweenness values next to the no 4. Vantörsvägen and the no 10. Älvsjö station projects and in a large area of change outside of all TAs close to Gamla stan in the inner city with both strong positive and negative numbers.

d) Finally, a fourth measure was added where *changes in numbers of 250X250 squares with top 80% core betweenness values on citywide and project TA level were counted* to determine if there had been a change in distribution of the foreground network. An increase in distribution would indicate that more areas in the city are subject to greater through movement, flow of people, hence a greater diversity in public space. Results showed that there was a citywide increase in number of squares by >10% indicating that the foreground network covered a larger area in 2019 than in 2012 hence providing an increased potential for through movement, connecting more areas to the foreground network in the city

**Table 6**: Changes in number of 250x250 squares with top 80% betweenness values between the axial maps from 2012 and 2019 compared with project targets on decreased segregation.

| Difference in 2012–2019 | Count core value 2012 | Count core value 2019 | Count core value diff |
|---|---|---|---|
| **City Wide** | **630** | **694** | **64** |
| 1. Annedal | 12 | 12 | 0 |
| 2. Hornsbergsstrand | 38 | 38 | 0 |
| **3. NDS Hjorthagen** | 0 | 7 | 7 |
| **4. Vantörsvägen** | **18** | **21** | **3** |
| **5. Stora Sköndal** | **23** | **19** | **-4** |
| **6. Beckomberga** | **31** | **30** | **-1** |
| 7. Henriksdalshamnen | 13 | 13 | 0 |
| 8. Sofielundsvägen | 24 | 24 | 0 |
| **9. Ågestabroväg** | **23** | **21** | **-2** |
| **10. Älvsjö station** | **21** | **20** | **-1** |
| 11. Jakobdalsvägen | 17 | 17 | 0 |
| 12. Liljeholmskajen | 16 | 16 | 0 |
| 13. Kv. Snöflingan | ¨- | - | - |
| 14. Blackebergs gård | 7 | 7 | 0 |
| 15. Johannelundstoppen | 27 | 27 | 0 |

| **Project target alignment with citywide targets to decrease segregation** | **Negative** | **No** | **Some** | **Full** |
|---|---|---|---|---|

On project TA level, the number of squares was intact in nine of the projects whereas two projects had a positive change and four a decrease. Of all projects with a targeted positive change in their project descriptions, only the no 3. NDS Hjorthagen project was successful. The no 4. Vantörsvägen project stands out again but this time with a positive number despite the weak intent in the project documentation. Four projects, 5. Stora Sköndal, 6. Beckomberga, 9. Ågestabroväg and 10. Älvsjö station was subject to negative change and the remaining TAs stayed intact.

### 3.3 Access to rail bound public transportation (RPT)

Analyzing the changes in access to RPT, three indicators were chosen. These were *the change in number of address points within 400 meters walking distance to a station entrance, the change in average and maximum distance in meters from address points to RTP station entrances*.

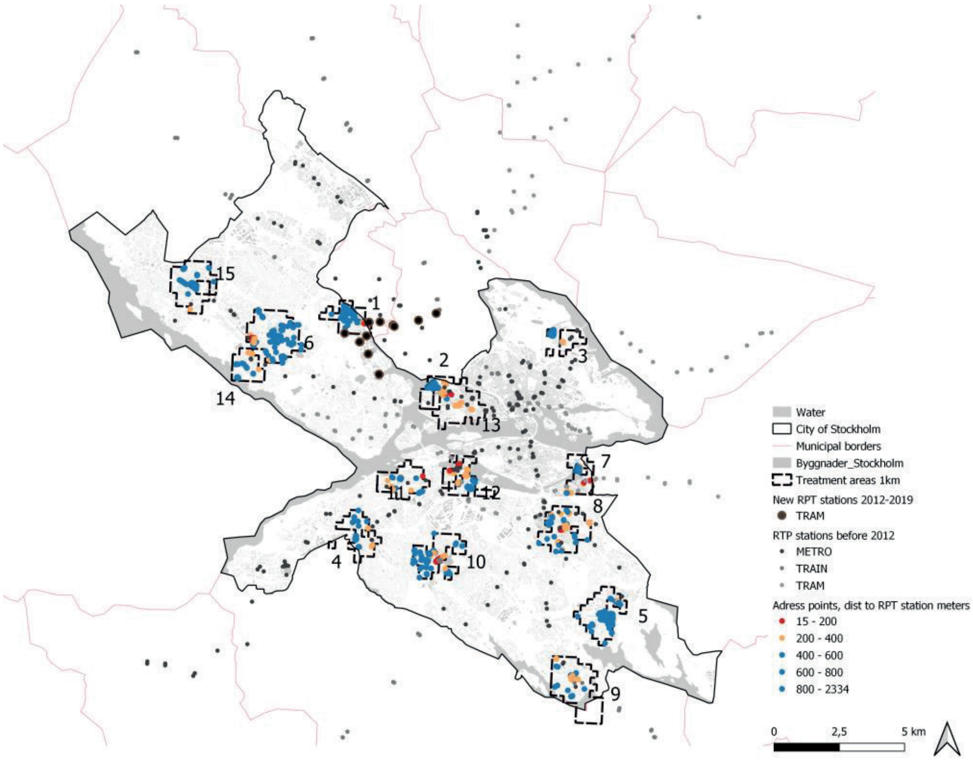



**Figure 8**: Access to RPT for the new addresses constructed 2012-2019 in the TA´s. Blue color indicates address points with distances >400 meters, not in line with targets.

On citywide level, the share of address points having 400-meter walking distance or less to a station entrance remained constant on 28% over the years. The average distance to RPT in entire Stockholm decreased, from 861 to 848 meters while the maximum distance decreased even more from 7502 meters in 2012 to 6056 meters in 2019. Analysing the performance in the 15 selected projects TAs, the share of address points within 400 meters from a RPT station stayed intact on 30%. Average distance to public transport decreased from 791 m 759 m and maximum distance from 2606 m to 2422 m. Overall, address points in the TAs where in general closer to RPT compared to citywide level but the new projects did not contribute to a positive change over the years, indicating that as many new units were added in locations further away from RPT.

**Table 7**: Changes in access to RPT compared to targets on citywide and TA level.

| Project | No of address points 0 - 400m to RPT diff | Average distance (meter) diff | Max distance (meter) diff |
|---|---|---|---|
| **City Wide 2012-2019** | 0% | -13 | -1446 |
| **All treatment areas 2012-2019** | 0% | -32 | -184 |
| **1. Annedal 2012–2019** | **1%** | **-492** | **-314** |
| 2. Hornsbergsstrand 2012-2019 | - | - | - |
| **3. NDS Hjorthagen 2012–2019** | **-11%** | **71** | **1000** |
| 4. Vantörsvägen 2012–2019 | 0% | 0 | 0 |
| 5. Stora Sköndal 2012–2019 | -1% | -56 | -184 |
| 6. Beckomberga 2012–2019 | 1% | -10 | 71 |
| 7. Henriksdalshamnen 2012–2019 | -4% | -16 | -129 |
| 8. Sofielundsvägen 2012–2019 | 2% | -10 | 0 |
| 9. Ågesta broväg 2012–2019 | 1% | -5 | 0 |
| **10. Älvsjö Station 2012–2019** | **4%** | **-656** | **-289** |
| 11. Jakobdalsvägen 2012–2019 | -1% | 2 | 0 |
| 12. Liljeholmskajen 2012–2019 | -1% | 3 | 0 |
| 13. KV Snöflingan 2012–2019 | - | - | - |
| 14. Blackebergs gård 2012–2019 | 0% | 5 | 14 |
| 15. Johannelundstoppen 2012–2019 | 0% | -23 | -54 |

| **Project target alignment with citywide targets on public transportation** | **Negative** | **No** | **Some** | **Full** |
|---|---|---|---|---|

Compared to targeted change in individual projects, actual change in two projects stands out on the positive side, 10. Älvsjö with a 4% increase in addresses within 400 meters and a decrease in average and max distance and 1. Annedal with a 1% increase of addresses and a large decrease in both other metrics as well. On the negative side, the 3.NDS Hjorthagen project stands out with an 11% decrease of addresses within 400 meters from RPT and increasing distances on average and maximum level.

### 3.4 Improved location value

The below table reveals that the most prominent change on citywide level was the decrease in maximum distance to RPT and distribution of foreground network, however the contribution of the TAs to these targets remained low.

**Table 8:** Changes in access to RPT and foreground network compared to targets on improved location value on citywide and TA level.

| Difference in 2012-2019 | No of address points within 0 - 400m to RPT | Average distance to RPT (meter) | Max distance to RPT (meter) | Local AB5k _core _dif | No of squares with local AB5k_core value |
|---|---|---|---|---|---|
| **Citywide** | 0% | -13 | **-1446** | | **64** |
| **All treatment areas** | 0% | -32 | -184 | | 2 |
| **1. Annedal** | **1%** | **-492** | **-314** | **3%** | 0 |
| 2. Hornsbergsstrand | - | - | - | - | - |
| **3. NDS Hjorthagen** | **-11%** | **71** | **1000** | **6%** | **7** |
| 4. Vantörsvägen | 0% | 0 | 0 | -12% | 3 |
| **5. Stora Sköndal** | **-1%** | **-56** | **-184** | **5%** | **-4** |
| 6. Beckomberga | 1% | -10 | 71 | 2% | -1 |
| **7. Henriksdalshamnen** | **-4%** | **-16** | **-129** | **2%** | **0** |
| 8. Sofielundsvägen | 2% | -10 | 0 | 2% | 0 |
| 9. Ågestabroväg | 1% | -5 | 0 | 2% | -2 |
| **10. Älvsjö station** | **4%** | **-656** | **-289** | **6%** | **-1** |
| 11. Jakobdalsvägen | -1% | 2 | 0 | 1% | 0 |
| 12. Liljeholmskajen | -1% | 3 | 0 | 1% | 0 |
| 13. Kv Snöflingan | - | - | - | - | - |
| 14. Blackebergs gård | 0% | 5 | 14 | 1% | 0 |
| 15. Johannelundstoppen | 0% | -23 | -54 | 1% | 0 |

| **Project target alignment with citywide targets on improved location value** | **Negative** | **No** | **Some** | **Full** |
|---|---|---|---|---|

Among the projects with planning targets on improved location value, no 1. Annedal and 10. Älvsjö station performed the best with an increase of address points in the TA, a decrease in both average and maximum distances and a rise in core betweenness values. The results from 3. NDS Hjorthagen project and the 7. Henriksdalshamnen project however, reveals negative tendencies in count of address points with access to RPT.

# 4 DISCUSSION

## 4.1 Observations reviewing planning documents on citywide and project level

As stated in the results section, the MCP documents vary in level of detail over the years; there is also little consistency in writing. Tracking of targets over the years can only be done by target areas not in direct linkage. Despite that the national legal framework and the physical city remains more or less the same over the years. Different reasons might be claimed to cause the current inconsistencies, such as changes in political will and legislation, which resulted in MCPs becoming more policy oriented and less strict.

When analyzing how citywide targets have been transferred to project level it is important to acknowledge that preconditions for planning differ between projects and that not all targets can be met by all projects. Urban planning and development are acts of will and choosing between conflicting targets is part of every project process. Nevertheless, change on the citywide level can only be achieved through the many small changes in projects over time. Hence, it is important in all projects to consider the possibilities and consequences of the choices we make.

In the planning and building act (PBA) one strict demand on zoning plans is to answer the question if the planned development is in line with the MCP or not. The question is difficult to answer, MCPs being documents containing a multitude of conflicting targets. Nevertheless, the 15 projects in this paper all responded that they were in line with the MCP, pointing at the project's compliance with the suggested land use in MCP from 1999. Other than that, very few references are made. The description of the purpose and scope of the zoning plan projects is mostly brief and describes the size and main purpose of the project (e.g. residential development). The text often has a strong focus on objects, the buildings, not systemic change. The remaining text in the zooning plan descriptions deals with local qualities such as nature/geology, the character of the development, commercial services, accessibility, streets and traffic parking, types of mobility, traffic volumes and networks and the like but without direct reference to the MCP. This weak linkage between targets in MCP and zoning plan documents makes it difficult to conclude in what way a specific project is meant to contribute to citywide target completion or not. This missing linkage, in combination with long timelines and a limited understanding of the complexity of the built environment, might be contributing factors leading to project decisions that are at times out of context, contributing to low target completion on citywide level. In any process, decisions are made at distinct moments in time based on available knowledge. Here, a comparison to a similar problem relating to decision capabilities that arise in digital and automated processes might be in place, namely the occurrence of an “out of the loop” crisis. This concept represents situations where the human operator of an autonomous system suddenly suffers situation awareness problems as described by e.g., Bolstad et al (2006); Endsley & Kiris (1995) and a loss of skills, that makes them unable to operate manually in case of system failure (Bolstad et al., 2006.). The operators in this case are relying on, e.g., the vehicles capacity to operate, hence reducing their own attention and overview of the situation. In urban planning, situation awareness is instead hampered by long timelines, target inconsistencies and limited understanding of the complexities of urban systems. It is our belief that the use of digital tools in performing quantitative analyses of configurational properties in cities to understand the consequences of interventions on urban systems, in combination with a better linkage between targets in MCPs and targets in the latter stages of the planning process, can decrease the occurrences of such “out of the loop” decisions.

## 4.2 Configurational analysis

The analysis of changes on citywide level in integration and betweenness measures are as expected small but the indication of a direction of change can be identified. The low number in new axial lines listed in table 3 indicates that the interventions in this period did not involve large revisions of the overall network in Stockholm. However, considering the complexity of the development process, as well as in the normalization of values (e.g., Hillier et al, 2012; SHPUZA, 2017) one should be careful with drawing far-reaching conclusions based on this, and it is also a reason why studying the distribution of relative changes across the city is of central interest. That said, it indicates that there is a slight positive impact in line with the municipality’s targets.

More interesting is the analysis on project level where the combined analysis can give a more straightforward answer as to whether the project contributed to citywide performance.  In the TA of project no 5. Stora Sköndal, there was a comparatively large addition of axial lines indicating heavy investments in new road infrastructures but the change in integration values was negative at all scales, only the betweenness value in the project went up. This might be expected of a project in the periphery of the city, but it raises a question on what measures that can be taken to improve connections to surrounding areas even in such locations.

In the analysis of access to RPT, the change in maximum walking distance reflects a change in the network that was achieved due to the expansion of the light rail RPT system in the northwestern part of Stockholm. Nevertheless, the total accessibility to RPT in Stockholm stayed the same, indicating that a large portion of the projects started did not contribute or even had a negative impact on this target. We might get an explanation for this by looking at targets of improved location value (table 8) where the 1. Annedal and 10. Älvsjö station projects performed the best but for different reasons. In 1. Annedal, new stations on the RPT line to Solna was completed next to the TA. In 10. Älvsjö buildings were instead added close to the existing RPT entrance. Interesting enough, several other project documents included targeted future RPT stations that for some reason were cancelled or postponed. This is the case in the 3. NDS Hjorthagen, 4. Vantörsvägen, 7. Henriksdalshamnen and the 15. Johannelundstoppen projects. Public transportation is a regional responsibility in Stockholm, and this points out that there might be room for improvements coordinating the expansion, as has also been shown in previous research by (e.g., Börjesson et al, 2014).

## 5 CONCLUSIONS

The results of this study show that there is a gap between planning targets and the change in the city realized through interventions in urban development. On a citywide level target to reduce segregation have been vaguely successful but the small changes indicates that a greater change could have been possible. This points out a necessity to improve the target orientation function in the urban planning and design process. We suggest that these improvements could be achieved through an increased use of digital tools, and an increased consistency of targets in planning documents over time and scale. To realize this, a more systematic approach to the definition of targets and indicators is needed. By clarifying the targets in the MCPs and i.e. giving them measurable KPIs and using them as headings in templates for zoning plan projects, more relevant questions regarding goal alignment between MCP and project level and consequently between targets and project outcome could be asked e.g. “to what extent does this project contribute to the targets in the MCP”. A question that would make follow-up procedures and goal orientation in the processes possible.

The lack of success also raises questions regarding the current legislation with non-binding overarching strategies in MCPs and programs and binding zoning plans focusing on isolated areas of the city within an administrative boundary. With a digital approach, planners could develop and deploy methodologies in an agile way across scales and planning stages in the planning process to keep track of change and more importantly, to sketch the impact of interventions in future scenarios. Such a procedure will however require a new way of connecting and organizing urban planning processes, building new knowledge on targets, indicators and the built environment in verified digital models of the city that span over time and scale.

## ACKNOWLEDGEMENTS

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## APPENDIX

**Table 9**: list of data used in the paper.

| Data | Source | Comment |
|---|---|---|
| Axial maps from 2012 and 2019 | Legeby 2012, City of Stockholm 2018 | Updated 2022 |
| Completed projects between 2012 and 2019 | Stockholm municipality, 2019 | |
| Polygons of Buildings in Stockholm | Stockholm municipality, 2019 | |
| Address points in Stockholm | Open-source data from Tefat, Stockholm municipality, 2018 | |
| Rail bound public transportation stations 2012 and 2019 | From Stockholm planning administration, 2019 | |
| MCP of Stockholm from 1999, 2010 and 2019 | Stockholm municipality, 2019 | |
| Program- and zoning plan documents of 15 projects | Stockholm municipality, 2019 | |

**Table 10**: list of configurative analyses with explanations.

| Name in the table | Full name or formula | What it corresponds to |
|---|---|---|
| **NI_ Network integration*** | | |
| **Nis6_12sc** | Network Integration 6 steps, rescaled, year 2012 | Local scale, 2012 |
| **Nis6_19sc** | Network Integration 6 steps, rescaled, year 2019 | Local scale, 2019 |
| **Nis16_12sc** | Network Integration 16 steps, rescaled, year 2012 | Neighbourhood scale, 2012 |
| **Nis16_19sc** | Network Integration 16 steps, rescaled, year 2019 | Neighbourhood scale, 2019 |
| **Nis50_12sc** | Network Integration 50 steps, rescaled, year 2012 | City scale, 2012 |
| **Nis50_19sc** | Network Integration 50 steps, rescaled, year 2019 | City scale 2019 |
| **Dif_s6_sc** | Dif_s6_sc = Nis6_19sc - Nis6_12sc | Difference in local scale |
| **Dif_s16_sc** | Dif_s16_sc = Nis16_19sc – Nis16_12sc | Difference in neighbourhood scale |
| **Dif_s50_sc** | Dif_s50_sc = Nis50_19sc – Nis50_12sc | Difference in city scale |
| **AB_Angular betweenness** * | | |
| **AB2k2012sc** | Angular betweenness 2 kilometres, rescaled, year 2012 | Potential for the through-movement, neighbourhood scale, 2012 |
| **AB5k2012sc** | Angular betweenness 5 kilometres, rescaled, year 2012 | Potential for the through-movement, city scale, 2019 |
| **AB2k2019sc** | Angular betweenness 2 kilometres, rescaled, year 2019 | Potential for the through-movement, neighbourhood scale, 2012 |
| **AB5k2019sc** | Angular betweenness 5 kilometres, rescaled, year 2019 | Potential for the through-movement, city scale, 2019 |
| **2k dif sc** | 2k dif sc= AB2k2019sc – AB2k2012sc | Difference in neighbourhood scale |
| **5k dif sc** | 5k dif sc= AB5k2019sc – AB5k2012sc | Difference in city scale |
| * Each variable is rescaled to 0-1 scale, where '1' corresponds to maximum value for the chosen scale. Years 2012 and 2019 are rescaled together to be able to calculate the difference | | |

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