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Combining Space Syntax with building density, land usage, public transport and property rights in Bergen city

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STRATEGIES FOR INTEGRATED DENSIFICATION WITH URBAN QUALITIES

Combining Space Syntax with building density, land usage, public transport and property rights in Bergen city.

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ABSTRACT

Bergen city in Norway is presently undergoing an enormous population growth. In this respect, Bergen municipality wanted to identify all the possibilities for densification in the current situation. Therefore, the following issues were evaluated: street network and public transport accessibility, building density, degree of functional diversity, restrictions on (private) properties and current land use plans.

Our approach is to analyse the central areas in Bergen in the current situation to discover how the urban transformation takes place in a natural way. Firstly, we studied the relationship between street network accessibility (with the Space Syntax method), degrees of FSI and GSI on building density (with the Spacematrix method) and degrees of function mix (with the MXI method). Secondly, we wanted to reveal the legal issues that arise from the strong Norwegian property rights. Thirdly, we added the accessibility of public transport lines through the angular step depth in the Space Syntax analysis. We combined all these issues by using GIS. Unlike in earlier research (Ye and van Nes, 2013 and 2014), the buffer line function in GIS was used to correlate building density, function mix and degree of spatial integration.

It turns out that the degree of street network integration affects the location of commercial activities and the degree of building density and function mix. When the street network accessibility increases on a local and global level, property owners start to submit plans that exploit their properties to the utmost. The same occurs around public transport stops with frequently running light rail trams. As follows from the theory of the natural urban transformation process, densification can thus be steered by improving the street network accessibility on multiple scale levels, combined with high public transport accessibility.

KEYWORDS

Building density, land use mix, property rights, public transport, natural urban transformation.

1. INTRODUCTION

During the last years, the use of GIS has contributed to combine the results from spatial analyses with place-bound socio-economic data. GIS has made it possible to operate with big data and to combine them with one another. The combination of building density (the correlation between FSI with GSI), degree of function mix (MXI) and Space Syntax in old and new towns has contributed to knowledge on how these aspects are interrelated (Ye and van Nes 2013 and 2014; van Nes et al., 2012). Already now, an outline is formulated for a theory of the natural urban transformation process. According to this theory, the spatial configuration of the street and road network influences the degree of building density and the degree of multi-functionality in the natural transformation processes in neighbourhoods over time (Ye and van Nes 2014). Lively and vital urban environments are thus dependent on a combination of a highly spatially integrated and well-connected street pattern, high building densities and a high degree of function mix.

Current planning policies in Europe are putting smart growth, high building density and high diversity of urban functions within short walking distances on the agenda to create compact cities. However, the social and environmental sustainability of building a compact urban form is disputed (Rådberg 1996:385). The compact city has the advantage of short walking distances between buildings containing its various activities. The ecological footprint is relatively small due to a reduction of urban sprawl. There are advantages to social and economic intensity because a high number of people live close to each other. From an environmental perspective, energy usage of transport between functions in compact cities is low. However, there is a lack of green spaces for recreation or for agricultural activities. Green and sustainable cities on the other hand have positive connotations in terms of well-being, attractiveness and sociability. The green city has the advantage of being able to provide its inhabitants with recreation and possibilities to produce food. In contrast, green cities contribute to urban sprawl into the countryside when the city expands. This contradiction between green cities and compact cities continues to prevail in urban design and practice (Rådberg 1996).

High building density is considered to contribute to sustainable development because it implies sharing of buildable space, facilities and infrastructure, as well as the reduction of travelling distances. This sharing implies a reduction of land use and energy resources required to perform all kinds of urban activities. The degree of success of this sharing can thus be seen as an indicator for an area's degree of urban quality.

If density is desirable as one of the requirements for urban quality, then urban development projects should always facilitate for maintaining, and where possible, further increasing density. Jane Jacobs (2000) and Jan Gehl (2011) argue that sufficient density is a requirement for life between buildings. More importantly, life between buildings is "potentially a self-reinforcing process", in which, "once this process has begun, the total activity is nearly always greater and more complex than the sum of the originally involved component activities" (Gehl, 2011:73). In other words, a successful urban area is self-propelling by merit of the amount and duration of outdoor activities, which requires both sufficient density and high-quality public spaces to ensure that a high number of people enjoy using these spaces.

Therefore, if density is a prerequisite for sustainable use and the amount of outdoor activities an indicator for the degree of success of performing these activities, then a spatially integrated urban street network is the primary generator of sustainability in the context set out here (see also: Hillier et al., 1993).

The next step is now to reveal how public transport accessibility plays a role in the natural urban transformation process. In 2009, Bergen city in Norway opened a light rail connection. The line was extended in 2016 and the last part of it will be opened summer 2017. The effect of the light rail is that surrounding property prices are increasing. For that reason, public transport accessibility was included in the calculations of street network accessibility by mapping the angular step depth from public transport stops.

One obstacle for large scale urban planning and transformation of urban areas in Norway is the strong legal issues related to private property rights. It is even stated in paragraph 105 of the Norwegian constitution law from 1814 that no one should be dispossessed of their private property, and if so, they should be given full compensation (Backer and Bull 2016, p. 12). Therefore, urban expansions in Norway tend to take place on large plots where one has to deal with a low number of property owners. Large-scale urban renewal projects or big inner city transformations thus involve time-consuming negotiations with property owners and adjustment of property borders, as well as high costs of changing property borders when a large number of owners are involved.

The background for the research is a project set up by Bergen municipality that intends to explore where and how to densify in existing urban areas. The aim is to use the outcomes in future land use and policy planning as a strategy for densification in the central areas of Bergen. Inspired by the 'Denser Stockholm' project (Spacescape 2013), a Spacescape analysis is made using a densification rose to identify both the need for densification and there where there is freedom to do so. How to densify in those areas depends on the degree of accessibility of the street network and public transport, as this inquiry shows. To that end, the Space Syntax method is included in the research project.

The project started with an identification of the types of densification actions proposed by the municipality. Three types of densification actions were identified: intensification, transformation and expansion. The intensification strategy entails identifying densification potentials in existing urban areas without changing the whole built environment. The transformation strategy concerns identifying and assessing densification potentials of larger urban areas that would require a functional transformation, such as harbour fronts, goods terminals and industrial estates. The expansion strategy intends to find densification opportunities in previously unbuilt areas within the city boarders. In the Bergen case, these are often found on the mountain slopes, where development had not previously been considered due to costly technical challenges.

Following the theory of the natural movement economic process (Hillier et.al, 1993 and 1998), it is to be expected that the highest potentials for densification outside the city centre are found around the main routes, the local centres and the public transport stops. Local discrepancies may be found which can likely be attributed to the unique landscape elements such as the mountain slopes and fjords surrounding the city. They are also responsible for the characteristic capricious road pattern, which follows height lines in order to keep gradients acceptable from a road-engineering point of view.

2. DATASETS AND METHODS

With the aim of producing maps in which Space Syntax, Spacematrix, Mixed-Use Index and property ownership data are combined, two new ways of visualising integration levels have been tested. This method goes further than the raster method introduced by van Nes, Ye and Mashhoodi (van Nes et al., 2012; Ye and van Nes, 2013, 2014) (see figure 1).

With the first method, the integration levels contained within the line segments are projected onto the building plots adjacent to these segments. This is achieved using an Overlay operation in ArcMap. The method is chosen because the building plots themselves contain the data that the integration levels are aimed to be combined with, i.e. the data on density and functional use as well as information on ownership of the plots.

The second method combines Space Syntax data with Spacematrix and the Mixed-Use Index with a buffer area around the line segments, since there are a number of inaccuracies in the initial results from the grid-based method. The overlay method works well for smaller plots, especially if they are connected to only one or two line segments. However, in particular on larger plots, values are found that often do not represent the actual degree of integration based on their position in relation to the street network.

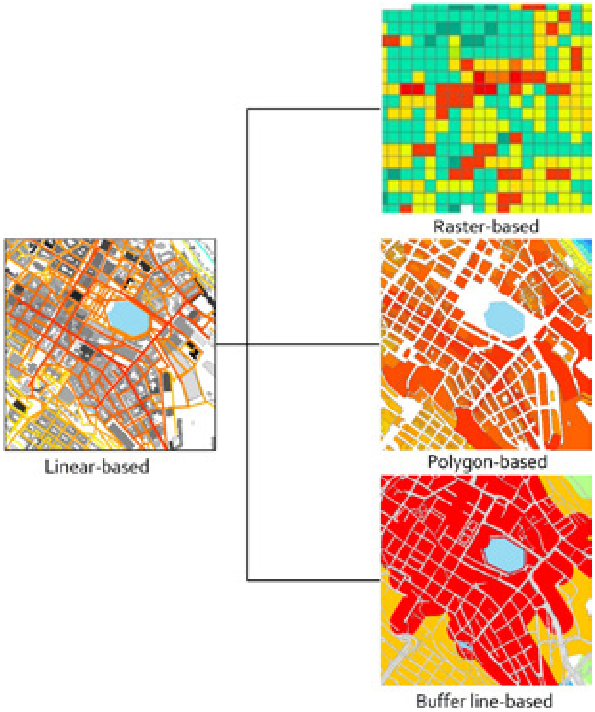

Figure 1 - Examples of raster-based, polygon-based and buffer line-based Space Syntax maps in GIS

The best example of this inaccuracy is the plot belonging to the goods terminal east of Bergen's railway station (figure 2). Directly connected to the globally and locally highly integrated street Strømgaten, this large plot thus receives a "highly integrated" classification. In reality, however, the plot is for the larger part flanked by line segments with much lower integration values than the map suggests. Moreover, the plot today is isolated and difficult to approach, and elongated to such an extent that only a limited percentage of people would approach it from Strømgaten, but most others from other streets located closer by.

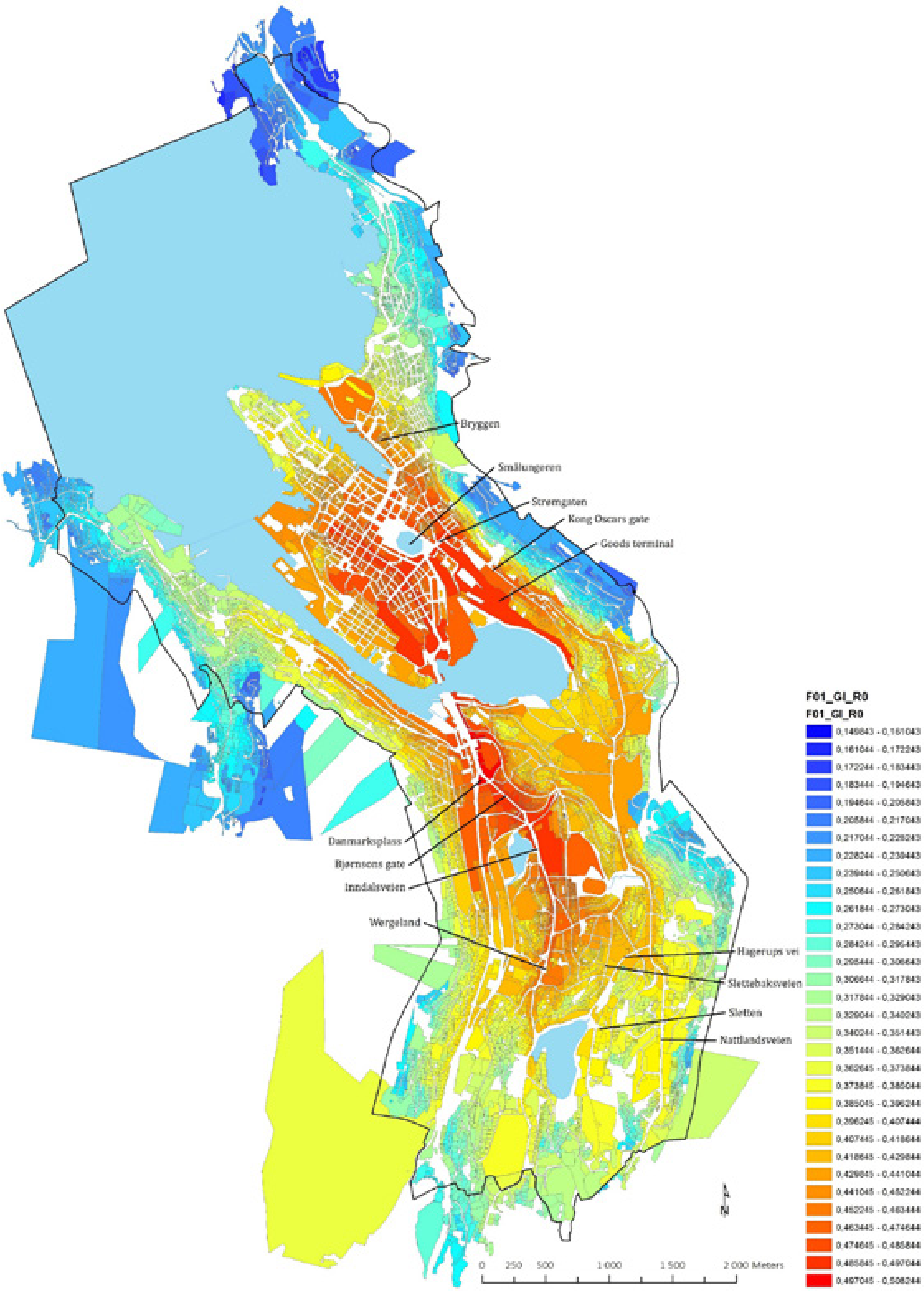

Figure 2 - Global integration map projected on building plots

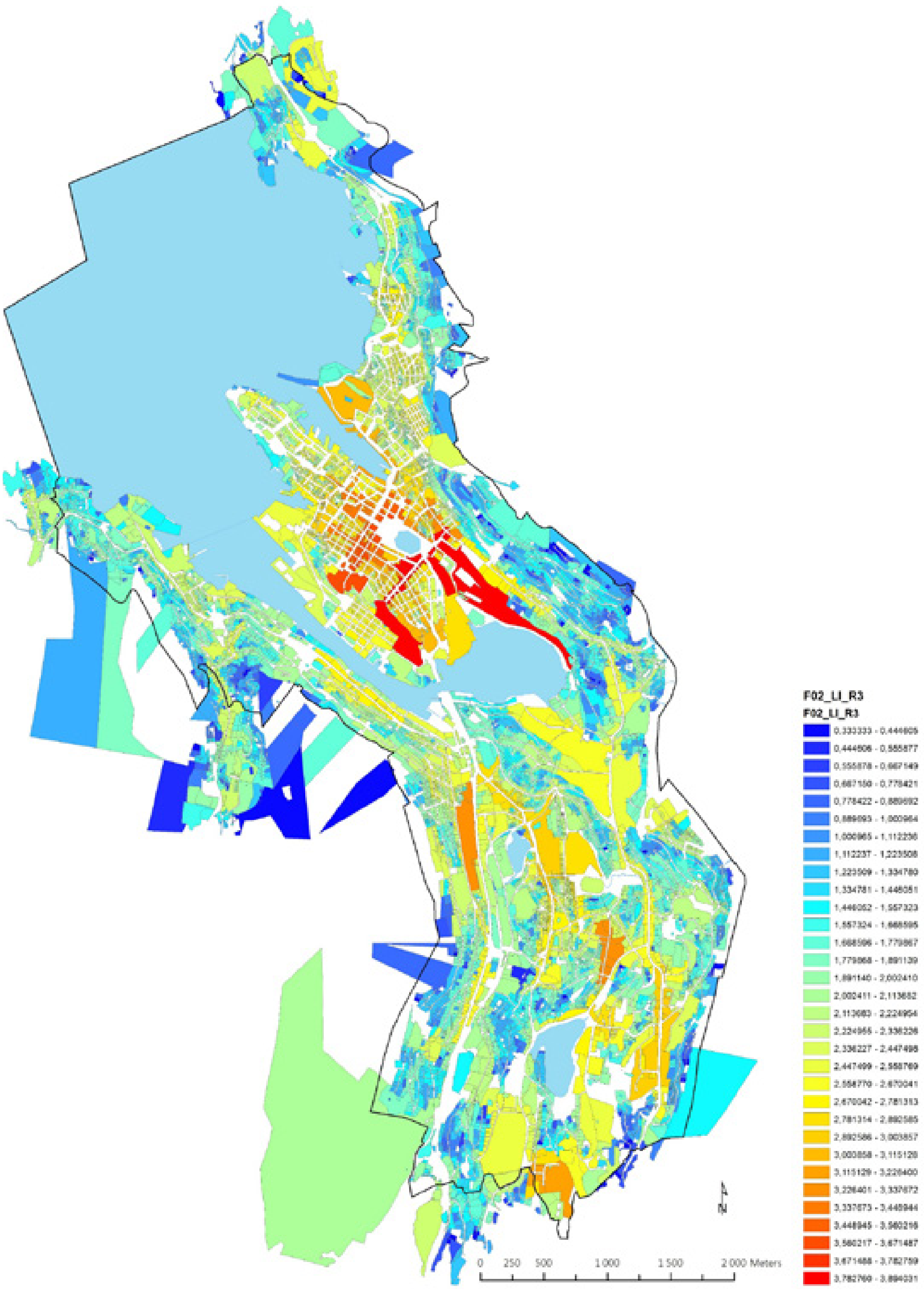

Figure 3 - Local integration map projected on building plots.

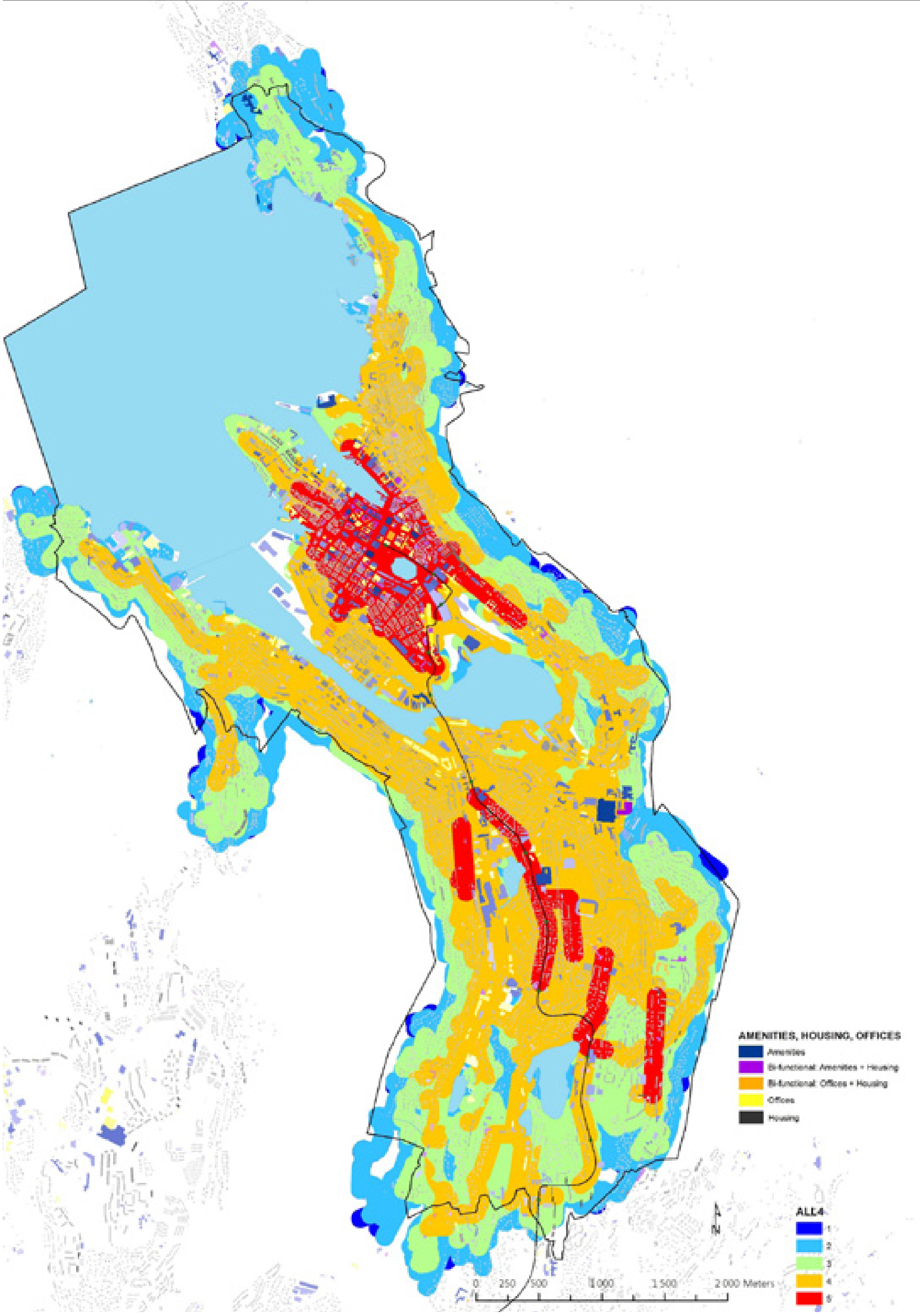

Figure 4 - Aggregated integration map using 75m buffer lines

To avoid this deviation from actual integration values on larger plots, a buffer operation is tested out as a second method. With a buffer of 75 meter around each line segment, a surface area is created that contains the corresponding integration value of that segment.

To identify the segments with high potential for both to- and through-movement, the global and local integration values have been multiplied with each other and combined with the multiplied metric step depth values with both high and low radii. The result is an aggregated map that reveals the overall integration values based on the location in relation to the street network. In addition, the building function is visualised by colour according to the Mixed-use Index and simultaneously, the building height is indicated by the gradient of the colour in question.

3. RESULTS

In figure 2 and 3, the global and local integration values have been projected onto the building plots. The highest global values are found in the city centre area where there is an orthogonal street structure, introduced in the first decade of the twentieth century. The high values extend out of the centre along the main axis that leads past the Danmarksplass area. This axis has evolved over time by different road upgrades to facilitate the rapid growth of vehicle transport. Since 2009, Bergen's first light rail line runs parallel with the highway. The highest density and degree of function mix is found along this highway axis.

The orthogonal street network structure yields the highest local integration values in the city centre around the Smålungeren area (figure 3). However, there are no other local areas outside the city centre where equally high values are found. This lack is not only limited to the built-up slopes, where both the road structure becomes more parallel to limit the gradient and there is an edge effect, but is also found throughout the urbanised valley.

It becomes clear that the street pattern throughout the city (outside of the city centre) has been constructed for facilitating car traffic through the large topographic variations in the landscape. This has produced a curvier road pattern with fewer cross connections than in cities located in a flat landscape. Moreover, road engineers have the largest influence in Norwegian urban planning. In detailed land use plans, all new streets and roads are planned in detail, whereas the land usage along these streets and roads is merely indicated with a function and with a degree of building density.

Taking into account that Bergen's street pattern is imposed on an extreme sloping landscape, the aggregated map in figure 4 was produced to reveal the areas with the best accessibility on both city level and local level, whilst including choice of route based on angular deviation. Again, the highest values are found in the city centre. Moreover, several main streets are well-integrated on a local level, such as Bryggen and Kong Oscars gate in the centre, Bjørnsons gate and Inndalsveien leading up to Wergeland, Slettebaksveien and Hagerups vei north of Sletten, and Nattlandsveien as the main road on the east side of the valley.

These red areas are undergoing a considerable degree of urban transformation in terms of increased density of the built mass. Ground prices in these areas are rising. New building projects have larger floor space and more storeys than the old buildings. The amount of commercial establishments is also increasing. The trajectory of the light rail line has subsequently connected these centres with each other. Most areas around these centres, marked in orange, are relatively well-integrated, although further away, the values drop sharply.

As a test of the method, a close-up study was done of the area around Danmarksplass, an area that has developed incrementally over the last 80 years without any overall urban planning. The goal is to reveal how building density and degree of multi-functionality are strongly influenced by the degree of spatial accessibility of the street and road network. The local centre on Danmarksplass is located along one of the main routes leading towards Bergen centre.

Figure 5 Metric step depth with a high metrical radius at the Danmarksplass area with registrations of building height and degree of function mix

Figure 5 shows the metric step depth analysis with a high metric radius combined with the degree of function mix. Here, the main routes through and between various neighbourhoods are highlighted. Where the values are high, the degree of function mix and building density are high. Schools, restaurants and shops are located along the eastern side of the busy highway as well as a light rail stop. The narrow pavement on this side of the road is always frequented by a high number of people.

Figure 6 - Metric step depth low radius Danmarksplass

The same features can be seen in the metric step depth analysis with a low metrical radius shown in figure 6. In particular, a high degree of function mix occurs on ground floors of buildings where the values are high. Local supermarkets, food shops and snack bars are located along these locally highly integrated streets. There is a cluster of local grocery shops and retail in a local centre west of Danmarksplass, which has the highest locally integrated street. These shops predominantly serve local residents living in the vicinity. The connections for pedestrians and cyclists between the local shopping centre and the main centre in Danmarksplass, however, are poor. The highway through the area acts as a barrier and the two sides are only connected by two pedestrian subways. There are no pedestrian crossings on street level.

Figure 7 - Angular Step Depth From Public Transport Stops

Figure 8 - Functions projected onto axial lines

Serviced by a few bus lines, analysis of the angular step depth from public transport stops shows that public transport coverage is quite high in the Gyldenpris area west of Danmarksplass. However, the transformation from a suburban to an urban district seems to be hindered due to a segregated street pattern and a low socio-economic status. In contrast, the Kronstadhøyden area on the east side is not locally serviced by public transport at all. The street pattern is more curved. Moreover, the neighbourhood has a higher socio-economic status than the Gyldenpris area. This difference is for a large part due to sun conditions. Whereas the Gyldenpris area is in the shadow of a mountain most of the day, the Kronstadhøyden area has good sun conditions. Some new developments are currently taking place in the Møllendal area to the northeast and the Haukeland area to the east.

As an experiment, the degree of function mix was projected onto the axial lines (figure 8). The correlation between functional mix and integration values seems strong. Amenities (coloured in blue), to which most non-residential functions belong, are predominantly connected to main routes. Offices tend to be located on the side streets of these main roads, ensuring favourable accessibility both by car and by public transport, whilst mono-functional residential streets are clearly clustered away from the main roads.

4. DISCUSSION OF THE RESULTS

It turns out that developments in Bergen city take place in line with the natural urban transformation process. Well-integrated streets have more to- and through-movement than poorly integrated streets. Shops and businesses cluster around these streets and densities increase considerably in comparison to the situation prior to the new situation.

Seemingly, cities in Norway are currently transforming on an "anti-urban" track. Even though the intentions are to make compact cities, there are three drivers for urban sprawl in Norway. For the first part, urban developments are still steered by a strong emphasis on private car accessibility. New buildings are equipped with parking garages in the basement and often at ground floor level. As a result, building projects create poor urban qualities for pedestrians and cyclists. This stands in strong contrast with the municipality's formal ambitions to reduce the growth of car traffic with 50 % by improving the walking and cycling conditions in urban areas.

The second cause for the continuation of the anti-urban tradition is Norwegian property legislation. Although private property developments do result in space-efficient exploitation of building plots with high short-term profits, the flexibility and adaptability to adjust to changes on the long-term is lacking. Moreover, these private owners have the last word concerning the degree of multi-functionality. In addition, property owners tend to plan and build their properties to the current context rather than being future-oriented. Access from the public domain is hardly taken into account and private car accessibility is prioritised. Attitudes like these strongly affect the organisation of public spaces that link the properties to the public street network. Disappointingly, this often results in an incoherent, anti-urban structure with inward oriented buildings that lack active frontages towards the public streets.

The third aspect is the hilly Western-Norwegian landscape. Technical innovations now give way to previously impracticable or unrealisable plans, although they are expensive. Moreover, carrying out functional changes in a later stadium would be much more demanding. Therefore, any possible short-sightedness from private developers could produce a building stock that is hard or expensive to adapt to new uses.

The method of projecting integration values onto building plots can be a useful tool in Norwegian planning. By linking integration values directly to building plots, the authorities can take measures that oblige privately owned properties to be developed with the urban qualities related to accessibility for pedestrians, cyclists and public transport, flexibility, multi-functionality and, in the near future, energy production, smart communication and sustainable mobility means.

The second method, using buffer lines, is more usable to locate densification potentials based on the position in the urban fabric. In addition, this method allows for quick identification of areas that are segregated as a consequence of the street pattern layout. The municipality and road authorities can use this method as input for overall development plans as well as infrastructural improvements, and subsequently predict the effects on building density and degree of diversity of such plans and measures.

The test analysis of public transport stops as a backbone for densification reveals that the influence of bus routes is insignificant in comparison to that of the light rail. This might be due to the comparatively long-term character of light rail lines, creating a certainty of passenger flows along these routes. The municipality is currently developing plans for three new light rail routes aimed at improving the accessibility to and from the city centre to the districts further away. It can therefore be expected that redevelopments will intensify more along these lines than the integration values based on the street pattern would otherwise suggest.

5. CONCLUSIONS

How can this research be used to make recommendations for Bergen municipality on where and how to densify? Evidently, the street network configuration influences the degree of building density and degree of function mix. Four types of urban areas were identified based on street network integration on local and global scales:

Type A: High local and high global integration of the street and road network.

Where extra space becomes available, these areas can be transformed with a high density of built mass. This can include high-rise buildings. The aim is to provide land use plans that allow a wide range of different usages, in particular on ground floor level. Areas suitable for this kind of development in Bergen are the city centre, the harbour areas around the city centre, Danmarksplass and the old industrial area Mindemyren.

Type B: High local, but low global integration of the street and road network.

Where there is space, these areas can facilitate high density of dwellings with ground floor spaces for shops, small businesses and services. Depending on the local circumstances, high-rise buildings can be considered as an option. As an example, the Sandviken area has many 2-3 floors high old wooden houses. The type and style of buildings give this area a particular place

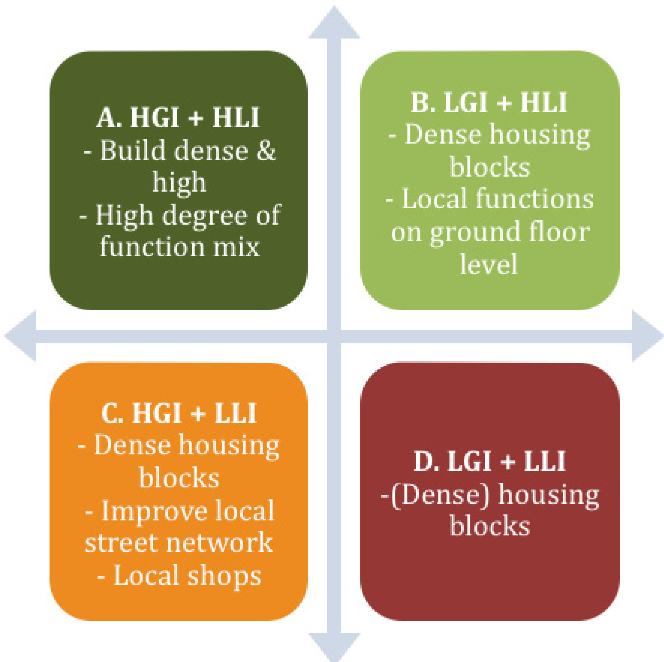

Figure 9 Strategic densification matrix

character. New buildings will have to adjust to the existing building stock in scale and style to avoid damaging the place-identity of that area. Areas suitable for this kind of densification are the various local centres outside Bergen centre. Most of these small local centres are situated along the main routes leading through various urban areas. Areas located along the light rail also belong in this category.

Type C: Low local, but high global integration of the street and road network.

These locations are suitable for high densities of housing. Where possibilities exist to create a locally integrated street network, local shops on the ground floor can be facilitated. An example of such an area is the southern part of industrial area Mindemyren.

Type D: Low local and low global integration of the street and road network.

Where there is space to develop, high densities of only dwellings are desirable. These areas have a low degree of accessibility, and are therefore little attractive for shop owners. Examples of these kinds of areas are found around the lake Store Lundgårdsvannet such as Møllendalsveien, and harbour areas located along the fjord Puddefjorden.

Figure 9 shows the principles on how to densify. The colours in the diagram in figure 9 are applied in the combined integration map of figure 10, showing how and where to densify in one map.

Four groups were used in this inquiry. It is also possible to use nine different groups where high, medium and low values of global and local integration are combined. This would enable the application of more detailed strategies. In this case, however, being in the beginning stage of collaboration with the municipality and in a planning process where multiple NGO's, property owners and stakeholders are involved, operating with four different categories rather than nine is more practical. In addition, the various densification strategies for each of the nine categories would need to be defined.

The experiments with the buffer line method are still in a test stage. The next step is to find ways to combine density, MXI and Space Syntax data into one buffer line model. The raster model is useful for overall strategic land use planning in whole urban regions or in regional planning. Professionals such as spatial planners and urban geographers may find this model useful. The polygon model is useful as a guide for urban designers and architects who work on plot level. Finally, the buffer line model can be useful for road engineers to make them aware of the spatial potentials of their planned road and street links. After all, the degrees of building density and function mix depend on the degree of spatial integration of the street and road network.

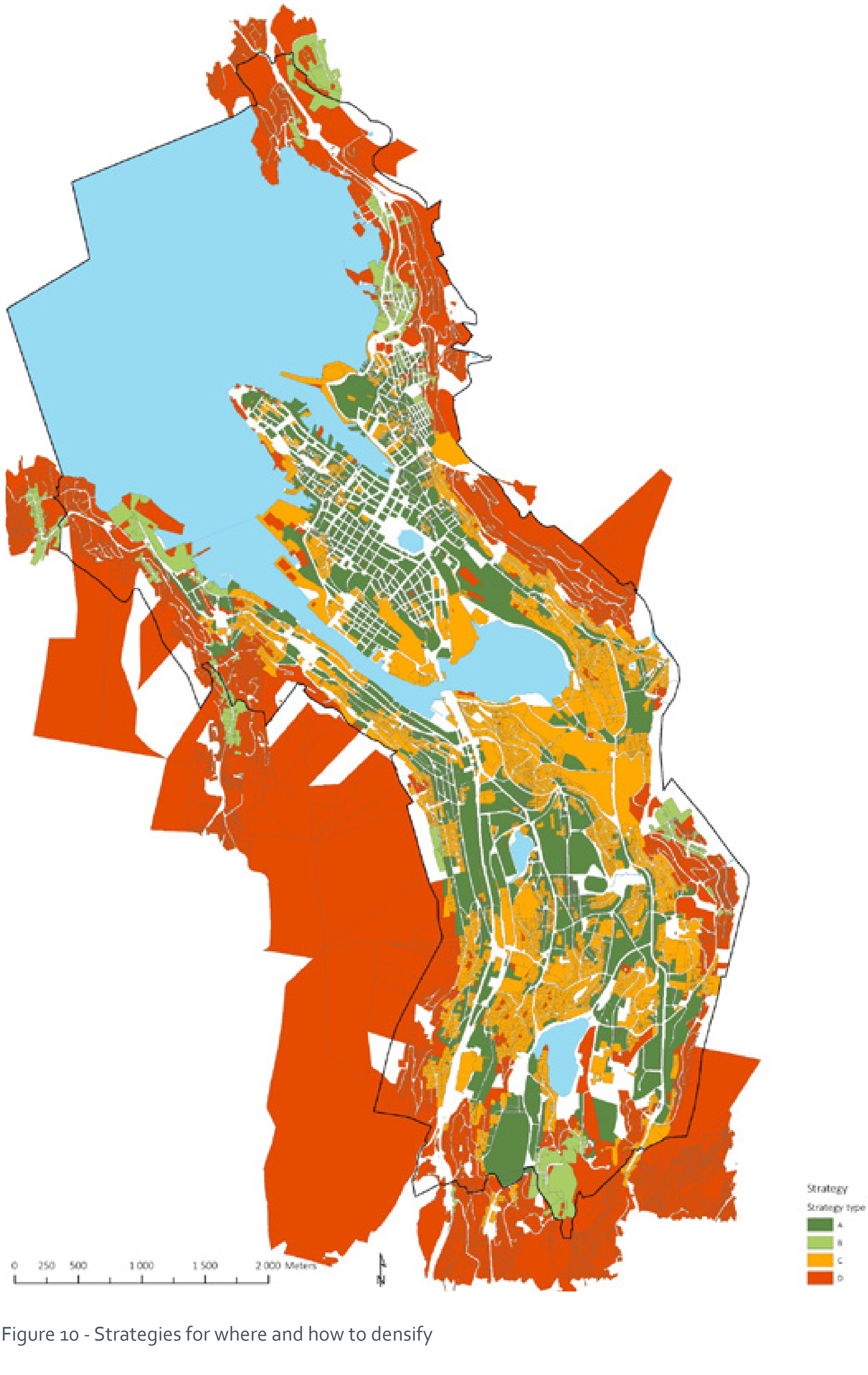

Figure 10 - Strategies for where and how to densify

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