Sustainable Densification and Greenification in the Inner City of Rotterdam

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Abstract

Many cities are developing and implementing plans for urban restructuring and densification. The Municipality of Rotterdam has explored a number of strategies with the aim of creating a more attractive, lively city centre through densification and greenification. This study has researched what the actual potential for densification is and which impact on urban environmental quality and sustainability can be expected. With geodata and urban modelling, an evidence base was created that charted the effects of the proposed plans. This paper discussed how this was done and how it supported that particular stage of the process. It is expected that such evidence bases can significantly contribute to co-creation. By clarifying the societal and business value cases for different stakeholders inherent to plans, investments, and by exploring alternatives, a common operational picture is created that reduces complexity, speeds up the process, and enhances quality of outcomes.

1. Introduction

European cities strive after a good urban quality of life. However, they have to attune to urban dynamics and to meet challenges in the urban living environment such as slow transition to clean and secure energy systems, limited adaptation to climate change, congestion, brownfields and obsolete real estate, and poor environmental and ecological quality.

Although these issues are generally acknowledged and many local authorities developed policies and took measures to address them, they cannot be easily solved. This can be partly attributed to an underdeveloped evidence-base for urban strategies and decisions. The lack of overview of potential solutions for these challenges, the poor insight into their effectiveness, wider impact, merits and drawbacks, and the geographical inertia implicit to urban structures, hinder the identification of solutions. As a result, scientific and practical knowledge is not optimally used when windows of opportunity occur in cities: for instance location development, infrastructure and transport investments, proposed energy savings and production measures, local sustainability initiatives of inhabitants, development of locations for new economic sectors and changing lifestyles with other residential and service needs. For the urban systems and networks as a whole this leads to a suboptimal use of the present urban systems and networks and a lack of sustainability and urban quality of life in its broadest sense (see also EC 2009).

At the same time, in the last years profound changes have occurred in the way urban interventions of any kind are dealt with. Urban planning has recognized the value of self-organisation and self-realisation, and moved from top-down, blueprint planning to facilitating and enabling bottom-up initiatives of urban stakeholders (Boelens 2009, Hajer 2011). With the effects of the economic crisis being increasingly felt in many European cities, the involvement of urban stakeholders in planning and realization and the combination of various business models have become quintessential to meet urban challenges. This requires understanding of incentives and obstacles for different stakeholders, of the societal and business value cases for different stakeholders inherent to options, and of the effectiveness of solutions in terms of contribution to sustainable, healthy, safe and vital cities.

These developments ask for both innovative governance approaches and a better developed evidence-base. Data and ICT can contribute to this evidence basis nowadays better than before for many reasons: open data standards have made data gathering much more easy and data quality much better, and ICT developments as social media and gaming technology have

fostered an intuitive, "real world" look and feel in tools and models. Gaming and visualization are powerful tools for learning and communication in an urban context: they can help to capture the knowledge from different stakeholders, clarify preconditions, frame opportunities and barriers, and motivate stakeholders to engage in difficult and "messy" questions (Sunesson et al 2008, Stahre et al 2008). By combining visualisation and gaming with urban modelling, the consequences of plans and interventions for urban sustainability and quality of the living environment can be demonstrated and evaluated (Kuijpers-Linde 2010).

This paper will discuss an example of the use of geodata and urban modelling for ex-ante evaluation of inner city densification plans in Rotterdam (Tillie et al 2012). After highlighting the plans for densification and greenification, the impact of the plans is shown in the form of a sustainability profile. After that, the effect of this evidence-base on local policy-making will be shortly summarised.

2. General trends of urbanisation across Europe

Although trends of urbanization in Europe are highly diverging, it is clear that in general dedensification has been the dominant trends across Europe in the last decades (Berghuis et al 2009, EEA 2009). Urban area expanded between 1990 and 2000 with approximately 1% yearly, while urban areas became less dense (-0.3% yearly), also when population declined. For the larger part urban expansion took place on agricultural land (83%) or on nature areas (15%). Between 2000 and 2006 these trends continued (EEA 2010). Nevertheless, within city regions, nations and across Europe, it seems polarization increases between economically successful, growing city regions and shrinking, less competitive city regions and agricultural regions. Long term societal trends are responsible for this pattern, in particular real income growth, connection to global economic networks, mobility, and increased space consumption by households and companies.

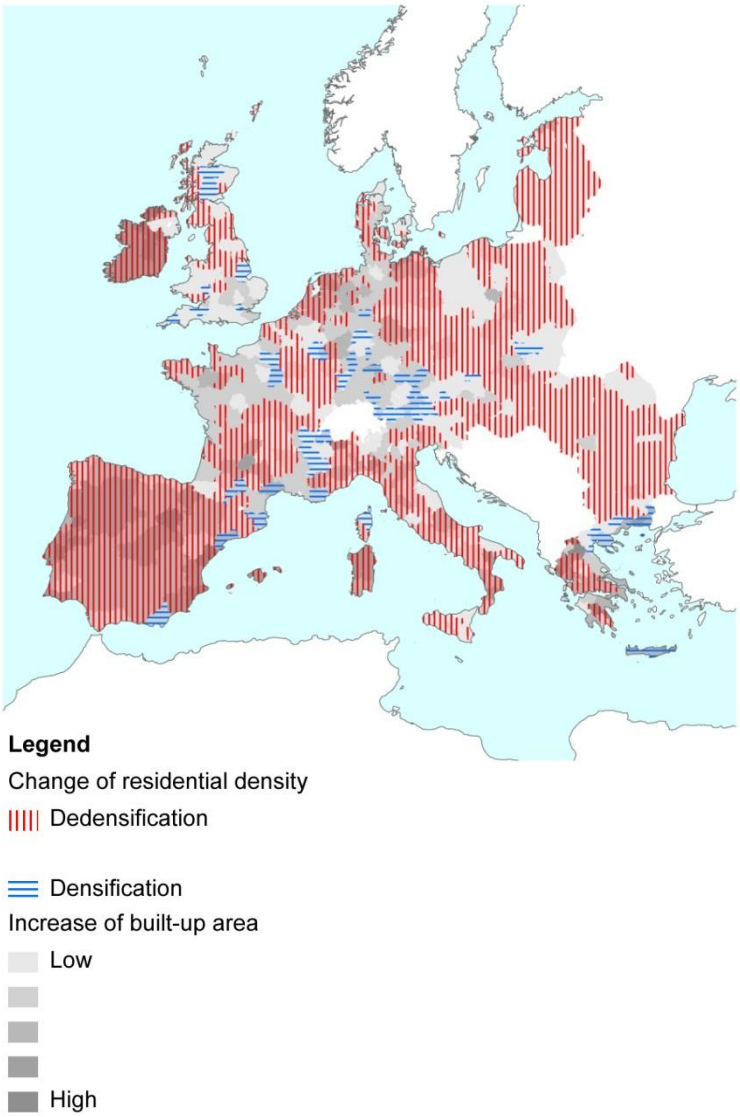

Fig. 1 Dedensification and expansion of urban land use in Europe
Source: Berghuis et.al. 2009

Although many scholars and local planning authorities consider densification as a prerequisite for sustainable urban ways of living, the advantages of a dense, compact city are not so certain for others. Will single-

family houses with a garden become an expensive luxury? Will more time be lost in traffic jams? Is it unhealthy to live in a densely built city? These are just a few of the questions that arise. On issues like these, it is important to distinguish facts from feelings. Therefore the opportunity to evaluate the impact of newly developed strategies for densification and greenification on the sustainability and spatial quality of Rotterdam's inner city was more than welcome.

3. Background

After consultation with stakeholders, in 2011 the Municipality of Rotterdam outlined its sustainability ambitions in a comprehensive programme (Gemeente Rotterdam 2011), which incorporates earlier policy initiatives such as the Rotterdam Climate Initiative. The desire to become the most sustainable harbour city in Europe through ecologically sound measures (with additional social and economic co-benefits), leads in combination with Rotterdam's vulnerability to flooding, sea-level rise and heavy precipitation, to a wide range of policy measures. These measures primarily aim at reducing risk related to climate change (Rotterdam Climate Proof by 2025); reduced use of fossil-fuel derived energy; reduced CO_2 emissions; reduced noise and air pollution; more sustainable transport of persons and goods; more public green; better use of waste heat; increased use of renewable energy, higher energy and resource efficiency in buildings, industry and transport; and carbon capture and storage.

These ambitions are reflected in the Municipality's vision on further spatial development of the city, which is meant to contribute to improving the quality of life for its citizens. The choice for compact and mixed-use urban development offers many advantages, such as less traffic and more support for urban facilities, although it does need to be accompanied by a better quality of the living environment in terms of public green, clean air, less noise pollution, and efficient use of energy (Gemeente Rotterdam 2007). For the inner city, it is thought that a combination of feasible options for densification and development of public and private green can create a more sustainable, but nevertheless compact, city.

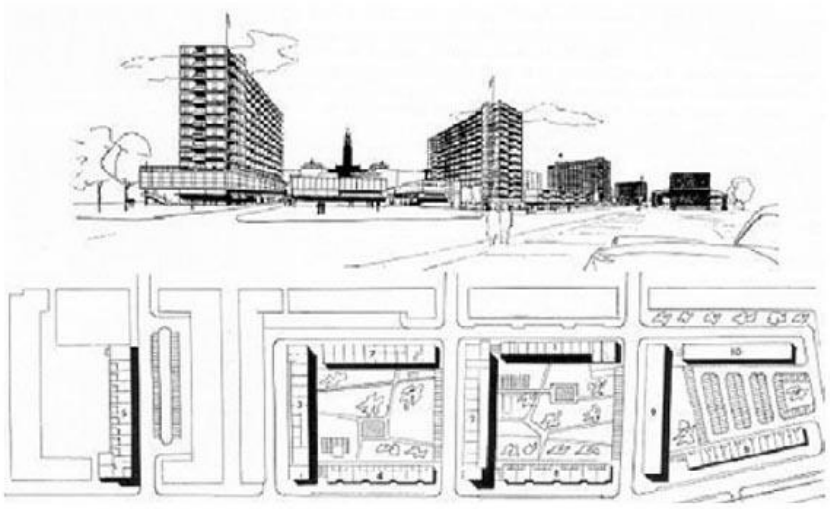

Fig. 1 Design of the Lijnbaan area in the early 1950's

The inner city of Rotterdam was heavily bombed during the Second World War and was rebuilt according to the standards of modern architecture in the 1950's: spacious, an alternation of high and low buildings, urban green, and the first pedestrian shopping street the Lijnbaan with 2-3 storey buildings and a at that time a very advanced logistic system (Figure 1).

Nearly 60 years later, it is thought that the city centre should be made more attractive. Exploiting the potential of the inner city can make Rotterdam more competitive and retain highly-skilled labour force. The current approach of adding high-rise buildings to the urban fabric should be replaced by a gentler, more varied approach. Vancouver is seen as a successful example of such a change. As a contribution to the International Architecture Biennale 2012 in Rotterdam, the Municipality of Rotterdam started an initiative where research and design were combined. This has evolved through a number of steps, each of which was built on the outcomes of the previous steps. To start with, a study by van Engelsdorp Gastelaars (Engelsdorp Gastelaars 1990) made clear just how sparsely populated the inner city of Rotterdam is when compared to other large cities in the Netherlands. In the larger cities of the Netherlands, about 10% of the city dwellers actually live in the city centre, but in Rotterdam that number is just over 5%, in spite of a rising trend. Because a city derives its liveliness

from its inhabitants, many more people need to live in the inner city if its vitality is to be guaranteed. Subsequently, in consultation with inhabitants and other stakeholders, a number of strategies for densification had proven to be successful. Architects had applied these strategies to the spatial structure of Rotterdam. Meanwhile, the Municipality of Rotterdam worked out a number of greenification strategies that will further enhance the attractiveness of the inner city. The hypothesis underlying this book is, therefore, that a combination of feasible options for densification and development of public and private green can create this more sustainable, but nevertheless compact, city. Lastly, TNO assessed the impact of these strategies on the quality of life in the city. Section 4, 5 and 6 will discuss densification, greenification and impact assessment in more detail.

4. Densification and greenification strategies

In co-operation with urban stakeholders as housing associations, project developers, inhabitants and businesses, seven strategies for densification were identified, which are illustrated in Figure 3. Existing plans for high-rise buildings are realized. Besides, redundant office space is transformed to housing. New ground-based dwellings are developed where this fits in the housing typology of the neighbourhood, space permits and urban green is suited for families. In water areas with favourable conditions, such as former harbour areas, water dwellings are built. Besides, new houses are added to the urban fabric in less obvious places: above and along streets (infill) or on top of other buildings (sky borne). Lastly, housing associations sell part of their property to young couples or families willing to renovate these houses completely, the so-called Do-It-Yourself houses.

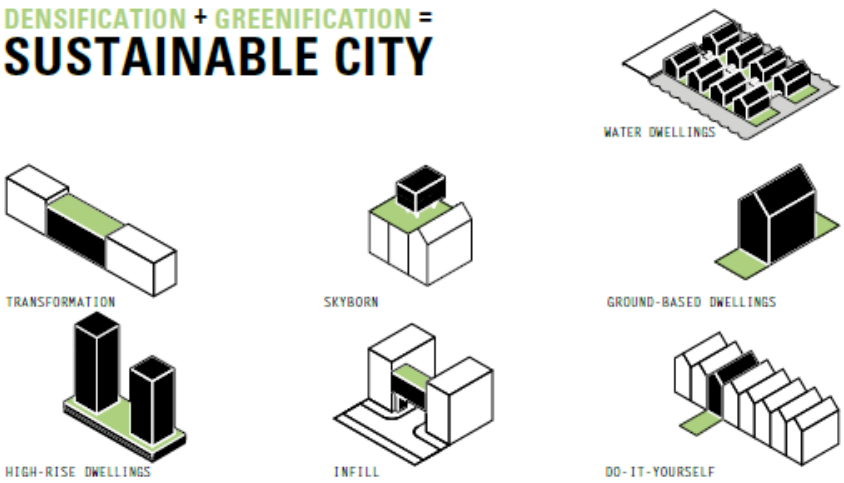

Fig. 3 Densification strategies for the inner city of Rotterdam

Doepel Strijkers Architects analysed the possibilities for densification in the inner city by investigating the potential for each densification strategy using municipal data on building block characteristics as construction, roof surface, ownership etc. In total, the potential for densification appeared to be more than 20.000 houses, with between 30-35.000 inhabitants. This would double the current number of inner city inhabitants to about 60.000.

Research in 2008 confirmed that, although Rotterdam has started catching up with a number of ambitious green redevelopment projects, more green space in the inner city is desired, as well as greater diversity in that green space and a better quality of green design and management. This implies that the construction of new dwellings should be accompanied by the provision of extra urban green, to compensate for previously unmet demand. In any case, to welcome the inhabitants that come with these new dwellings, more and better quality urban green is needed. An attractive green infrastructure in the inner city is conditional to the popularity of living in the inner city. The current green infrastructure needs to be expanded and complemented with new qualities. When the number of inhabitants will double, the area of public green will need to expand considerably in order to maintain the same quantity of green per inhabitant. This is, however, not only about the number of square metres of green per inhabitant, but also about the pleasant perception of the green space available, for which an attractive distribution of the greenery, with more differentiation in outlook and use, and improved spatial design are necessary. By continu-

ing to invest in high quality, green outdoor space the value of real estate, current and future, will grow, encouraging private investment in the inner city. The seven green strategies are expected to create and exploit opportunities. They are highly varied: creating attractive boulevards by adding rows of trees along streets, transforming quays to urban recreational landscapes, making attractive meeting places of urban squares, creating small new "post stamp" parks, adding extra playgrounds for children, transforming roofs and facades to urban green, and adding outdoor space of excellent quality. Together they show that the area of green space can be considerably increased.

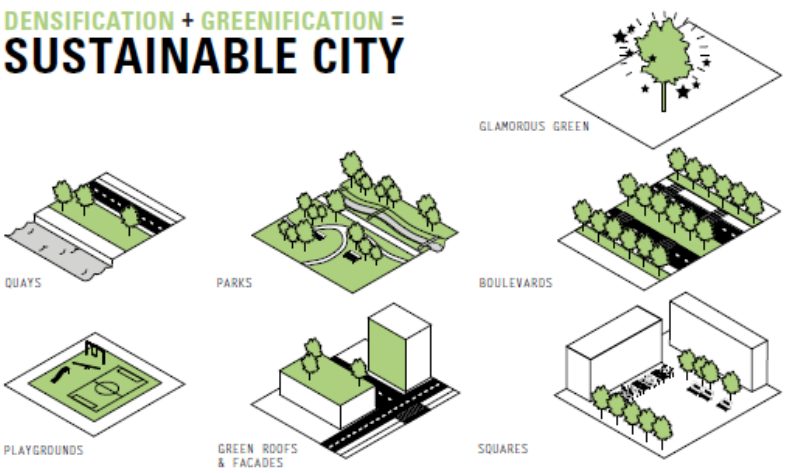

Fig. 4 Greenification strategies for the inner city of Rotterdam

5. Methodology Rotterdam Sustainability Profile

TNO studied the impact of the densification and greenification strategies on the quality of life in the city by developing a sustainability profile. As a first step, a framework consisting of 35 indicators was designed for the eight themes, such as "water system and climate change" and "accessibility". The themes distinguished in the Rotterdam Sustainability Profile cover the broad definition of sustainability, and thus include social and economic aspects as well as ecological and environmental ones (People, Planet, Profit). The subdivision into themes and indicators is roughly based on experiences of TNO with earlier sustainability assessments at the re-

gional level. The selection of indicators was based on their relation with urban densification and on the availability of data.

After that, a "zero" measurement of the Rotterdam Resilience Profile was made for 2011 for the themes in relation to the current inner city. Following this, the densification strategies as elaborated by Doepel Strijkers Architects were inserted in the Urban Strategy data storage, related models and the GIS.

Fig. 5 Indicators Rotterdam Sustainability Profile

Following, the values of the 35 indicators were calculated for 2040. To assess the impact of the proposed densification, the outcomes were interpreted: qualitatively by visual comparison, and quantitatively by summarising results and making additional calculations. Lastly, the values of the individual indicators were combined for all distinguished themes. The sustainability profile of the situation after densification is depicted in the spider diagram in Figure 8.

Fig. 6 Input of densification strategies to model framework Urban Strategy in yellow

The impact on sustainability of densification in the inner city of Rotterdam has been investigated by using the model framework Urban Strategy and its Energy Module to assess the impact of densification on eight sustainability themes . In addition, other models such as the economic model REGINA and the heat stress model SOLWEIG, as well as tools such as HIS (Flooding Information System) and sources of geodata have been used. The results have been analysed with Geographical Information Systems (GIS). Urban Strategy is discussed now in more detail.

Urban Strategy is an interactive decision support system that contains TNO's expertise in the local environment, involving aspects such as energy use, air quality, noise pollution, accessibility, external safety, urban green and CO2 emission (Brommelstroet and Borst 2012). The model has been developed since 2005. The effects of measures, interventions and investments on districts are shown directly using state-of-the-art models, including a newly developed energy module. Various types of changes in the urban environment, transport networks and underlying energy system can be modelled. The impact of these changes is calculated directly and made visible in mixed-reality, 3D models, 2D charts and so on within a matter of seconds or minutes. Urban Strategy links a central database containing data on the built environment (derived from datasets) to independent computer models. The exchange between these models takes place via a sepa-

rate communication layer. This enables changes in the results of the models to be immediately calculated into the other models.

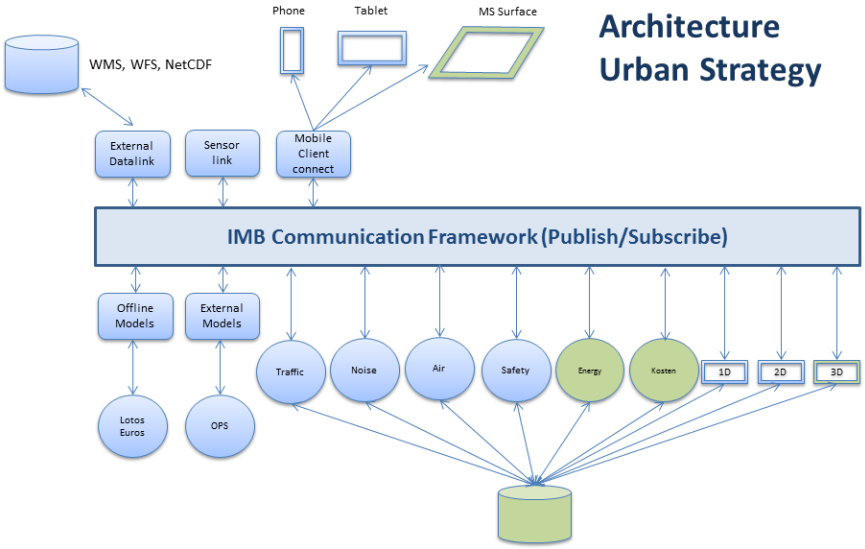

Fig. 8 Architecture Urban Strategy

Important advantages of the model framework are the integral approach of related aspects as traffic, noise pollution, air quality and external safety. Because different models use the same datasets, more consistency between data is achieved. Lastly, the simultaneous 3D visualization of urban morphology and indicators of environmental quality and sustainability improves communication between stakeholders.

6. Sustainability aspects

What do the outcomes mean for the inner city of Rotterdam in 2040? Unfortunately, space is lacking to discuss the outcomes in detail. Most maps and diagrams can be found in Tillie et al (2012). However, some general conclusions can be drawn on the impact on urban sustainability.

At first, it appears that although about half of the new houses will be realized by continuation of the policy of adding high-rise buildings to the current urban fabric, the potential for densification of other strategies is huge: about 10.000 houses in the inner city. This supports the idea that

many small opportunities for densification can together make a massive change, although it must be realized that inner city densification is highly complex to realise. However, so many new inhabitants will stress even more the urgency to improve quantity and quality of urban green, which will be used much more intensively. Current transport policy is based on an extra 5000 inhabitants in the city centre (City Lounge policies), which is far below the envisaged 30.000 to 35.000 new inhabitants in this study. This means transport policy is an integral and essential part of densification and greenification, and should in particular develop policies directed at modal choices, especially slow traffic modes, parking spaces and rates, logistics and distribution of goods, as it can be expected that the extra demand for automobile traffic and transport cannot be met with the current transport system.

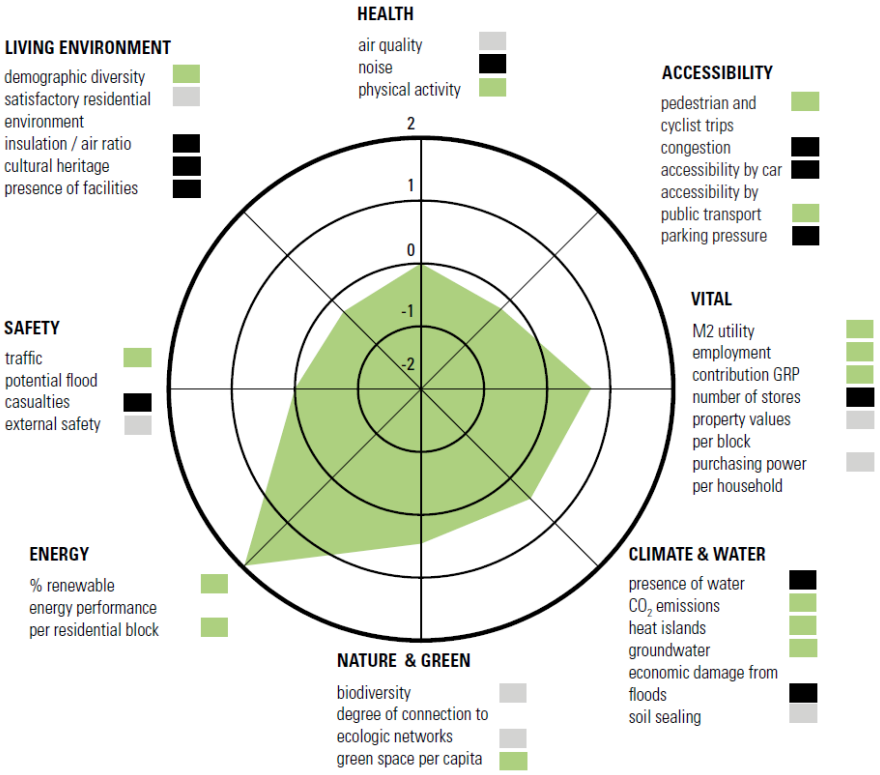

Fig. 8 Rotterdam Sustainability Profile

With respect to environmental quality and sustainability, it appeared that many indicators remained the same or improved as a result of densification

and greenification. For instance, heat development as a result of an increased total volume of buildings proved to be largely compensated by more shadow casted by higher buildings, and the effects of extra urban green. Regarding energy consumption, this will increase for the inner city because more houses and inhabitants consume energy. However, per capita it will substantially decrease due to the fact that new houses are much more energy efficient, while renovation, extra floors and urban infill will trigger measures as thermal insulation and instalment of photovoltaic cells. As there is no physical space to park all cars of new inhabitants, public transport and slow modes as walking and cycling will be more frequently used than now. Especially cycling will lead to more healthy living years, also when the effects of poor air quality at specific locations are taken into account. In combination with energy efficient vehicles, the lower or absent energy consumption of public transport, walking and cycling, will compensate to some extent for additional use of energy in the urban transport system. Congestion will increase, but as it concerns still relatively small flows compared to the voluminous traffic flows from the all over the agglomeration to the centre of commuters and freight, its effect is not that large. However, as traffic flows do increase and much more people are exposed to air quality and noise exceeding thresholds, these environmental quality aspects are not improving. The same goes for urban green: although greenification will enlarge the surface of urban green and its quality, it has to be used by much more people.

In short, the sustainability profile demonstrates that densification can contribute significantly to the quality of life in cities, in particular when more sustainable options for urban transport are realised, when public space is vibrant and of high quality, when facilities are attuned to growth in numbers of inhabitants, and when possibilities for improving energy efficiency are utilised.

7. Conclusion

The sustainability profile of densification and greenification made discussions on urban sustainability aspects very concrete for the Municipality and local stakeholders. After the project, the information in the sustainability profile served as a starting point for an investment program in the inner city. The information was enriched and completed with more detailed information and was then used to identify which locations needed most attention and where synergies could be achieved. So it can be concluded that the study helped to:

- Chart the potential for inner city densification
- Chart bottle necks as congestion, environmental quality, inefficient use of energy
- Chart the opportunities, for instance in the field of energy savings, economic development, sustainable mobility, development of urban green
- Explore the playing field with urban stakeholders

This project is a good example of what collaboration between designers, scientists and society can achieve to produce a better quality of life in cities. The evidence-base constructed in this study has contributed to improving the way in which scientific and practical knowledge on cities, their dynamics and the quality of the urban living environment is made available in community processes, by governance arrangements involving stakeholders, policy-makers and decision-makers, and using advanced forecasting, representation, visualization and modelling techniques.

From a methodological viewpoint the project was successful in constructing the evidence-base by combining data from heterogeneous sources and by performing a broad sustainability analysis based on Urban Strategy and related models. So far, Urban Strategy had been mainly used to support Environmental Impact Assessments.

8. Recommendations

Urban actors want to make a start with the realisation of their dreams, and the Municipality is facilitating this process. But money is scarce! For this reason, it is necessary to get some insight into the opportunities that the actors have to combine various business models: how can we make the inner city of Rotterdam through “smart” combinations of investments and benefits? So in order to support the process of realization – including self-realization – of densification, greenification, and urban sustainability, information is needed for the identification of likely options, to test their robustness under different circumstances and, where needed, to develop and use frameworks for regulation. Extension of the Rotterdam Sustainability Profile with different (sub)scenarios and information on financial aspects of plans and investments could be useful for this purpose.

A methodological recommendation is to work in iterations, allowing adjustment of the densification and greenification strategies when needed or wanted according to the outcomes of the impact assessment. This brings

more flexibility into the process: research and design are then reinforcing each other mutually.

Finally, the used model chains and model framework could be improved at specific parts, for example regarding transport, energy and possibilities for physical exercise as walking and cycling. After this study was finished, some improvements have already been realised, for instance with the beta-version of a new energy module in Urban Strategy.

References

Berghuis S., J. Borsboom, A. Bräuer, R. Folkert, H. Ottens (2009), Typologies of urban form dynamics in Europe. Paper prepared for 49th European Regional Science Association Conference, 25-28th August 2009, Lodz, Poland.

Boelens, L. (2009), The urban connection. An actor-relational approach to urban planning. Rotterdam, 010 Publishers.

Brömmelstroet, M. and H. Borst (2012), Vergroten van de bruikbaarheid van planningsondersteunende instrumenten - Een empirische toets van Mediated Planning Support en Urban Strategy als oplossingsrichtingen. In: Tijdschrift Vervoerswetenschap 48(3), september 2012, 29-49

EEA, METREX, ICLEI, University of West Midlands, ACE, NEAA (2009), Ensuring Quality of Life in Europe's Cities and Towns: Tackling the Environmental Challenges driven by European and Global Change. EEA, Copenhagen

EEA (2010), The European Environment. State and Outlook 2010, Urban Environment. Copenhagen, Europen Environmental Agency.

EC (2009), Promoting sustainable urban development in Europe. DG-Regio. Brussels, EC.

Engelsdorp Gastelaars, R. van (1990), Lezing ontwerp overleg gemeente Rotterdam. Rijksplanologische Dienst 1990.

Hajer, M. (2011), De energieke samenleving.Den Haag, Planbureau voor de Leefomgeving.

Kuijpers-Linde, M. (2011), Kuijpers-Linde, M. (2010), The Planning EIA and anchoring knowledge in provincial strategic plans. In: Hajer M, Gijzen J , van 't Klooster S (eds.) (2010) Strong Stories: How the Dutch are inventing spatial planning, pp. 216-229. 010 Publishers, Rotterdam

Stahre, B. S. van Raalte, S., I. Heldal (2008), Sketching Techniques in Virtual Reality: Evaluation of Texturing in an Urban Planning Model. VSMM '08 – Conference on Virtual Systems and Multi Media, Limassol, Cyprus, October 20 – 26, 2008

Suneson, Kaj; Allwood, Carl Martin; Paulin, Dan; Heldal, Ilona; Roupé, Mattias; Johansson, Mikael; Westerdahl, Börje (2008): Virtual Reality As a New Tool in the City Planning Process. Tsinghua Science and Technology, 13 (S1) pp. 255-260,

Tillie, N., M. Aarts, M. Marijnissen, L. Stenhuijs, J. Borsboom, E. Rietveld, D. Doepel, J. Visschers, S. Lap (2012), Rotterdam – People Make the Inner City. Densification + Greenification = Sustainable City. Publication Issued on the occasion of the 5th International Architecture Biennale Rotterdam (April-August 2012)