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Integrated Models: Planning Urban Sustainability

This policy brief offers local and regional planners an introduction to the world of integrated urban modelling. It provides information on their potential benefits, implementation process and current use in the Nordic city-regions. Nordregio's research into these types of models has been carried out in cooperation with WSP Analysis & Strategy, and was commissioned by the Nordic Working Group on Green Growth – Sustainable Urban Regions.

INTEGRATED URBAN MODELS (IUMs) provide planners with a decision-making support tool that allows them to visualise urban development strategies and assess their socio-economic and environmental impacts[i]. This type of tool is valuable for planners faced with the difficult task of balancing the many social, economic and environmental issues that affect spatial plans and strategies[ii]. They are also act as a useful support in dialogue with the diverse group of stakeholders involved in transportation, land use planning and urban development.

What are integrated urban models?

Integrated Urban Models are GIS-based modelling tools that support planners by developing and communicating urban development plans at a variety of scales – from the neighbourhood to the city-region. Depending on the specifics of each model, they use data reflecting the state of land use and the transport system, coupled with socio-economic information such as population projections and employment. The essence of the models is their ability to integrate this information in order to visualise development of the urban form, forecast the city's future social, economic and environmental performance and, through these outputs, test the potential impacts of different urban development policy strategies'. They generally have a long-term horizon, providing 30–50-year spatial development scenarios for cities, reflecting the implementation of different urban development strategies. For example, they can be used to estimate the impact of a change in transport infrastructure, such as a new subway line between two areas, or the development of a new urban district.

Key policy recommendations

■ IUMs should be considered by municipal and regional authorities in cities that have complex relationships between land-use planning, transport issues and the creation of attractive urban areas. This is especially evident in cities with a high potential for multi-modal public transport.

■ IUMs can be implemented by municipal and regional authorities looking for a holistic planning approach by testing the impacts of different proposals on the existing urban form. This especially includes an integrated land use and transport strategy, which is increasingly recognised as a crucial element of an attractive urban environment.

■ IUMs provide planning support to urban planners who have to make complex, interconnected decisions about urban development. They also serve as a communication tool that can inform policy-makers in a decision-making process by providing a better understanding of urban development and its consequences.

■ IUMs incorporate aspects of urban development that are planned, funded and implemented at spatial scales that do not always correspond to administrative boundaries. As such, they offer a means of generating a mutually agreeable vision among neighbouring municipalities and/or regional authorities.

Benefits

First of all, IUMs can estimate the potential social, economic and environmental impacts of different planning strategies, allowing for a more well-informed evaluation of the different planning options. These impacts can be presented using informative, easy to communicate visualisations, which can increase awareness of future urban development and provide a better understanding of how to mitigate negative consequences of urban growth.

Urban development provides many opportunities such as economic development and greater accessibility to social services. But it can also take place in response to a number of difficult challenges, including road congestion, housing shortages and poor distribution of public services, as well as increased energy consumption, noise and health concerns resulting from an increasing dependency on the private car[ii]. These challenges will often disproportionately affect vulnerable socio-economic groups and, if they are not acted upon in proactive and integrated ways, the negative consequences will undermine the positive effects of urban development.

A second benefit of IUMs is that they produce visual scenarios of urban development that facilitate participatory decision-making processes among a wide-ranging group of stakeholders[iii]. Consensus regarding which plans to pursue must be reached among a complex group of stakeholders who often have differing priorities. One example is politicians from neighbouring municipalities who are each pursuing their own land use development issues and, in many respects, competing for investment on a regional scale. Another example is regional authorities responsible for various aspects of the provision of public services (roads, public transport, schools, hospitals, etc.) and whose territorial claims stretches over many municipal borders. Also included are building investors, transport authorities, business organisations and the general public, all of which need this type of easily understandable analysis in order to make informed decisions.

Case: The Integrated Planning Model and its contribution to the Stockholm Regional Plan 2010

The Integrated Planning Model (IPM) was developed by the Swedish Transport Administration and WSP Analysis & Strategy. In the maps below, the two images on the left show the building density of two different areas in Stockholm in 2010. The maps on the right show the projected building densities in 2050, based on assumptions that different planning strategies have been implemented. In the "Suburban Sprawl" scenario (top right) building densities and the consumption of green space are not controlled by planning policy resulting is a large amount of additional land take as it is required in order to meet the expected population and economic growth. Conversely, the "Station Development" scenario (bottom right) adopts a public transport approach to urban development, concentrating higher densities around public transport nodes. This is very clearly shown in the image as existing areas of low density (blue) are developed further rather than developing currently undeveloped areas.

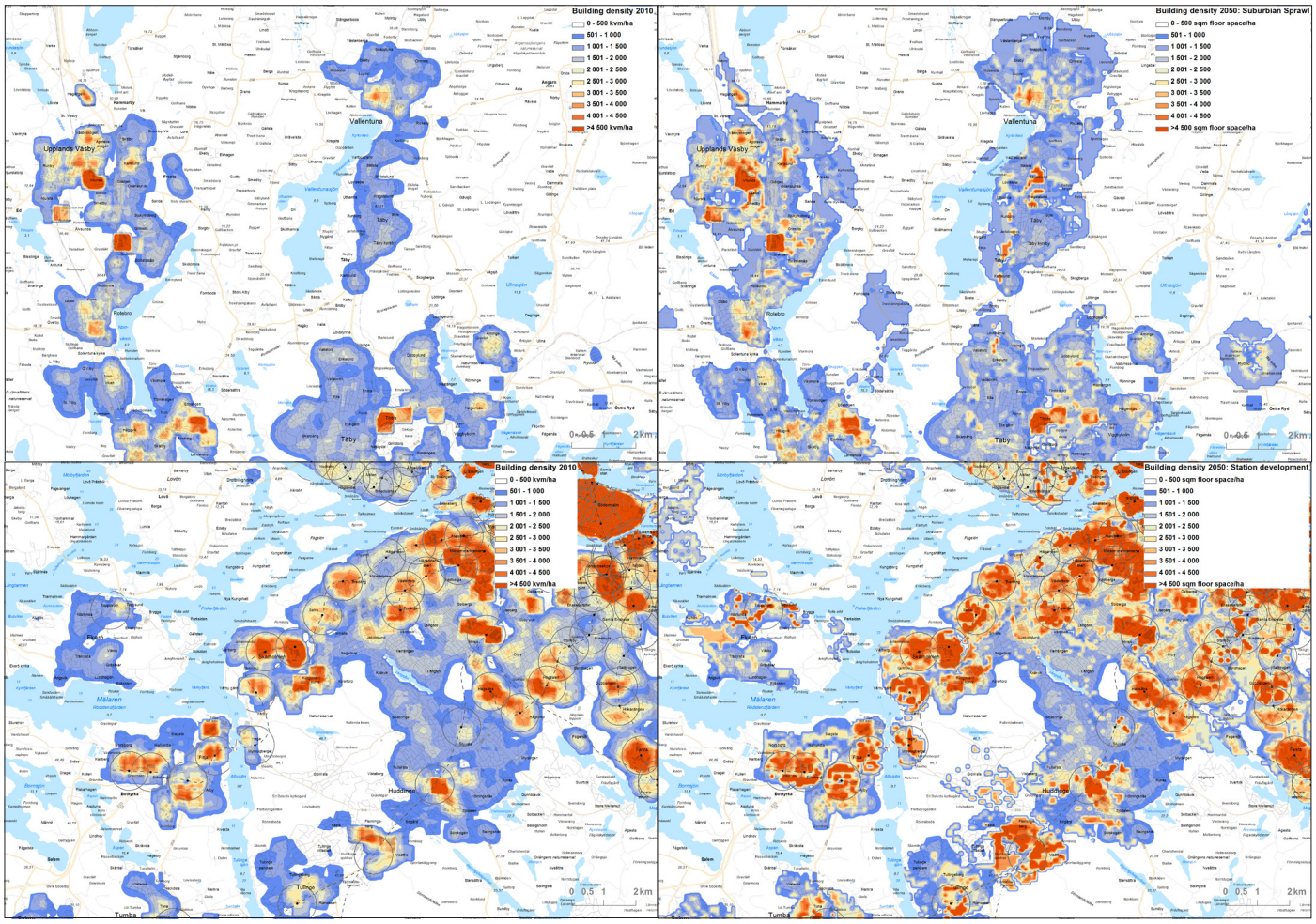

Figure 1: *The two images on the left show the building density in different areas of greater Stockholm in 2010. To the right, visualisations show the possible outcomes of different planning strategies on land use development. The top right image shows a large amount of additional land consumption in the "Suburban Sprawl" scenario, while this is significantly reduced in the "Station Development" scenario on the bottom right*[iv].

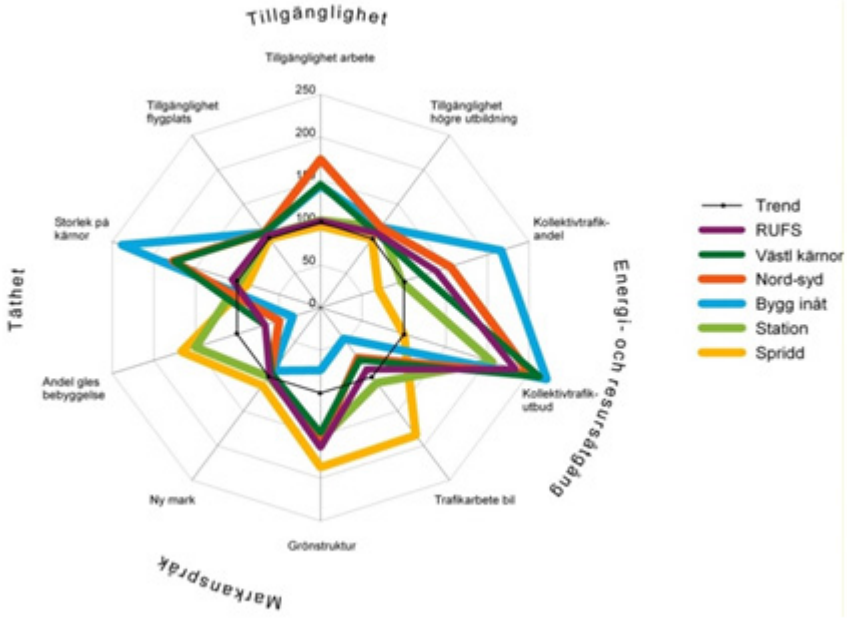

Figure 2: *Spider grams like this one can be used to effectively communicate the impacts of different urban development policies. Here, we see how six different urban development scenarios have been tested, and how the impacts can be easily compared with each other. In this case the focus is on accessibility, energy and resource efficiency, land use and compactness*[iv].

How to choose, implement and use integrated urban models

There are many different types of IUMs available as commercial or open source products. Most often, these are developed in academia and the most robust have been implemented in different urban contexts[v]. These models differ in a number of ways: in terms of what results they produce, the amount of data and preparation they require to produce results and how transferrable they are to different urban contexts. As a part of our work, WSP Analysis & Strategy produced an inventory, classification and assessment of some of the most common integrated models. An introductory list of the models is presented below with a link to the detailed tables. The general advice is that, if a planning authority has little or no experience with using IUMs, they will be best served by first considering one of the relatively simple rule-based modelling packages that are commercially available or can be implemented by consultants.

Furthermore, IUMs are not designed to build an urban development plan by making definitive statements about the future. Instead, their benefit is in their communicative value within a governance process, especially if there is a political will to support cooperation between the neighbouring municipalities of a city-region, or if a regional authority wants to set out a common vision for spatial development which includes the input and values of many municipalities.

Access to good data is a prerequisite for producing an insightful model. As a minimum, IUMs generally require long-term population and employment data for a region, as well as land survey data that includes the location of roads, built-up areas, preservation areas, etc. Real estate and property data is generally needed to provide additional information about building types and accessibility data is also required; the latter often being produced by separate transportation models. Last but not least, physical planning strategies are needed to define the scenario process and these are often developed through stake-

Key considerations when using an integrated urban model

- IUMs provide decisive statements about the future, but are not a substitute for a thorough planning process that includes the participation of and deliberation among key stakeholders. In this respect, they are designed to support a participatory planning process.
- Designing and implementing IUMs demands specific technical expertise in local and regional authorities. It is often necessary to consider involving external expertise.
- Simple, rule-based IUMs are likely to be more effective for authorities with little or no experience in using this type of planning tool.

Table 1. *Overview of existing urban models.*

Model name	Organization/Company/Institute	Comment
Clue-s	Institute for Environmental Studies (IVL), University of Amsterdam	Regional analysis of land use change/cover.
ICLUS - Integrated Climate and Land Use Scenarios	United States Environmental Protection Agency (EPA)	Generates scenarios of housing density changes. Several applications. Available free of charge.
I-Places3s (PLAnning for Community Energy, Economic and Environmental Sustainability)	Originally by Parsons Brinckerhoff, Fregonese Calthorpe Associates, and Space Imaging, in collaboration with ESRI.	A scenario planning tool to visualize scenarios and policy impacts. Several implementations, mainly in the USA.
IPM (Integrated Planning model)	WSP Sweden on behalf of Stockholm County Council	Owned by Stockholm County Council, but can be used with permission. Has been implemented in Stockholm Skåne and Tripoli (Libya).
Land Change Modeller	Clark University, USA	Land planning and decision support software extension to ArcGIS.
Land-Use Scanner	LUMOS (Netherlands)	A land use model that predicts demand for space. Software is available free of charge from LUMOS.
LEAM (Land-use Evolution and Impact Assessment Model)	University of Illinois, Urbana-Champaign	Outlines an approach for understanding the dynamics of urban systems and the potential implications of urban policy decisions.
LUSIS (Land-Use Conflict Identification Strategy)	University of Florida - GeoPlan Center	Goal-driven GIS model that produces a spatial representation of probable patterns of future land use divided into several categories. Based on ESRI software.
Metronamica	Research Institute for Knowledge Systems (RIKS)	Commercial software simulating changes in land use caused by human actions and natural processes.
MOLAND	Joint Research Centre, European Commission	Integrated framework to evaluate and propose strategies for the sustainable land use management.
UPLAN	Information Center for the Environment (ICE), University of California	A simple rule based urban growth model intended for regional or county level modelling.
URBANSIM	Paul Waddel	A software-based simulation system for supporting planning and analysis of urban development, incorporating the interactions between land use, transportation, the economy, and the environment.
What-IF	Developed by What if?, Inc.	GIS-based system that can be used to prepare long-term land use, population, housing and employment projections.

Current use of integrated urban models in the Nordic Region

There is a great deal of interest in IUMs among the research community and consultants, yet, according to a survey carried out by Nordregio in the Nordic countries, their use in practise is still very low. This is somewhat surprising considering the relatively strong tradition of comprehensive planning in the Nordic region[vi].

The perceived high cost of the models, difficulties obtaining the right data and the perception that the municipality/region is too small to justify using IUMs were identified as important reasons why integrated urban models have not been used. However, the survey indicated that the dominant reasons why models have not been used to date are that many planners are not familiar with IUMs and their benefits and that there is a shortage of planners with the right technical skills. It is therefore important that good information on their characteristics – including their benefits and weaknesses, as well as which types of urban region they are best suited for – is provided to those urban planners and policymakers who could take advantage of them in the future.

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Nordregio conducts strategic research in the fields of planning and regional policy. We are active in research and dissemination and provide policy relevant knowledge, particularly with a Nordic and European comparative perspective.

Resources

Nordic Working Group on Green Growth – Sustainable Urban Regions - This working group is interested in how spatial planning knowledge and instruments can contribute to the policy goal of green growth in Nordic city-regions. Nordregio's work has included a review of land use models[vii], a survey conducted on their use in the Nordic region[viii] and a policy workshop held at Nordregio in February.

Useful reading

Review of Land-Use Models by Lars Berglund, WSP Analysis & Strategy

Nordregio Working Paper – The Use of Integrated Urban Models in the Nordic Countries: Summary and Documentation of Online Survey

Planning Tools for Urban Sustainability, Nordregio News 2014, Issue 1

Endnotes

[i] The term integrated urban models are also commonly referred to as "land use/transportation interaction" (LUTi) models.

[ii] Serras, J., Bosredon, M., Herranz, R., & Batty, M rban Planning and Big Data - Taking LUTi Models to the Next level? Nordregio News, (1).

[iii] Batty, M., & Torrens, P. (2005). Modelling and prediction in a complex world. Futures, 37, 745–766. And Berglund, L. (2014). Review of Land-Use Models - Summary and Documentation. Stockholm, Sweden: WSP Analysis & Strategy.

[iv] Swedish Transport Administration and WSP Analysis & Strategy. Used with permission.

[v] Berglund, L. (2014). Review of Land-Use Models -Summary and Documentation. Stockholm, Sweden: WSP Analysis & Strategy.

[vi] Weber, R., Larsson, V., & Smas, L. (2014). The Use of Integrated Urban Models in the Nordic Countries. Stockholm, Sweden: Nordregio.

[vii] Berglund, L. (2014). Review of Land-Use Models - Summary and Documentation. Stockholm, Sweden: WSP Analysis & Strategy.

[viii] Weber, R., Larsson, V., & Smas, L. (2014). The Use of Integrated Urban Models in the Nordic Countries. Stockholm, Sweden: Nordregio.

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