NORDREGIO
Nordic Centre for Spatial Development

The Use of Integrated Urban Models in the Nordic Countries

Summary and Documentation of an Online Survey

Ryan Weber & Veronique Larsson

NORDREGIO WORKING PAPER 2014:1

The Use of Integrated Urban Models in the Nordic Countries
Summary and Documentation of an Online Survey

The Use of Integrated Urban Models in the Nordic Countries

Summary and Documentation of an Online Survey

Ryan Weber & Veronique Larsson

NORDREGIO
Nordic Centre for Spatial Development

The Use of Integrated Urban Models in the Nordic Countries
Summary and Documentation of an Online Survey

Nordregio Working Paper 2014:1

ISBN 978-91-87295-18-8
ISSN 1403-2511

Nordregio
P.O. Box 1658
SE-111 86 Stockholm, Sweden
nordregio@nordregio.se
www.nordregio.se
www.norden.org

Editors: Ryan Weber & Veronique Larsson
Cover photo: Johannes Jansson / norden.org. A portside urban quarter in Reykjavik, Iceland.

Nordic co-operation
Nordic co-operation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and the Faroe Islands, Greenland, and Åland.
Nordic co-operation has firm traditions in politics, the economy, and culture. It plays an important role in European and international collaboration, and aims at creating a strong Nordic community in a strong Europe.
Nordic co-operation seeks to safeguard Nordic and regional interests and principles in the global community. Common Nordic values help the region solidify its position as one of the world's most innovative and competitive.

The Nordic Council
is a forum for co-operation between the Nordic parliaments and governments. The Council consists of 87 parliamentarians from the Nordic countries. The Nordic Council takes policy initiatives and monitors Nordic co-operation. Founded in 1952.

The Nordic Council of Ministers
is a forum of co-operation between the Nordic governments. The Nordic Council of Ministers implements Nordic co-operation. The prime ministers have the overall responsibility. Its activities are co-ordinated by the Nordic ministers for co-operation, the Nordic Committee for co-operation and portfolio ministers. Founded in 1971.

Nordregio – Nordic Centre for Spatial Development
conducts strategic research in the fields of planning and regional policy. Nordregio is active in research and dissemination and provides policy relevant knowledge, particularly with a Nordic and European comparative perspective. Nordregio was established in 1997 by the Nordic Council of Ministers, and is built on over 40 years of collaboration.

Stockholm, Sweden, 2014

Contents

Foreword

How can urban planning contribute to create sustainable and attractive urban areas and at the same time support green growth in the Nordic city-regions?

This question is of course not answered by a single approach focusing on the spatial planning dimension alone but has to be approached in a broader and multi-dimensional manner. Focusing on the spatial planning dimension is however fundamental in planning and developing sustainable urban regions.

The *Nordic working group for green growth – sustainable urban regions* aims to develop policies, strategies and planning tools in close collaboration with the Nordic city-regions to support practitioners working with urban development on a regional and local scale. This involves bridging economic development, social well-being, physical planning, demographic changes, climate and environmental perspectives – which, when considered together, represent the complexity of governing urban development.

The purpose of the Nordic working group is to promote the development of sustainable and attractive Nordic cities and partly to promote these solutions in and outside the region for the benefit of Nordic companies' growth and jobs.

The Nordic working group is therefore interested in how spatial planning knowledge and instruments can contribute to the policy goals of green growth of Nordic city-regions. This includes knowledge on and development of modelling tools for urban areas to undertake spatial development in ways that facilitate policy goals and decisions associated with green growth.

In this report *Review of Land-Use Models* Nordregio emphasises the benefits of integrated approaches to planning. Through new sophisticated technologies and models, more and more factors can be considered simultaneously, which can provide more accurate future predictions of different planning strategies and policies.

I hope that the report's focus on integrated land use models can provide useful new information for policy decision-making on future urban planning questions.

Rasmus Kristian Pejter Rasmussen, Danish Ministry of the Environment

Chairman of Nordic working group for green growth – sustainable urban regions.

Summary

Integrated urban models (IUMs) can help us gain a better understanding of urban dynamics by creating simplified future scenarios that can be manipulated through simulation. They enable virtual experimentation, allowing the potential impact of new infrastructure, technologies or policies to be determined, which can support strategic planning. Models can also act as powerful tools for facilitating participatory, collaborative decision-making. The visual outputs provide a series of "what if" scenarios, dependant on the strategic policy decisions that are made.

This working paper presents the results of a survey carried out by Nordregio's researchers (with preparatory support from WSP Analysis and Strategy). It was distributed to municipal and regional planning authorities in the 29 largest Nordic city-regions. A total of 50 responses were received, with at least one from either a municipal or regional authority in each city-region.

The aim of the survey was to learn more about the use of integrated urban modelling tools by Nordic authorities through the following questions:

- To what extent are integrated urban models being used by Nordic planning authorities?
- What are the basic technical details of the models being used?
- How are these models developed, implemented and used as planning support systems?

Main findings

Of the 50 responses, 39 came from municipalities and 11 from regional authorities. There were 22 responses from Sweden, 12 from Denmark, eight from Norway, seven from Finland and one from Iceland.

Initially, 16 of the 50 authorities stated that they use IUMs; however, when the details of these models were clarified using subsequent survey questions, it was determined that only six of the 50 authorities use truly integrated urban models. This clarification presented us with a problem regarding how to interpret the remaining results of the survey. Therefore, we decided to move forward with the finding that, while only six of 50 respondents use truly integrated urban models, 16 respondents use some degree of urban modelling and with the realisation that the results they provide are still meaningful. Therefore, the term "IUM" refers to the six cases where we think truly integrated urban models are used, while the term "urban models" refers the 16 cases identified initially.

The skewed results are most likely due to the definition not sufficiently emphasising that models are tools combining two key components: the integration of multiple land use, transport and socio-economic attributes and the ability to produce future land use development scenarios. Nevertheless, it is surprising how few authorities use IUMs given the strong history of comprehensive planning in Nordic countries. This appears to be due to a lack of awareness of the uses and benefits of these models, which makes it important that new information be communicated to planners and policymakers efficiently.

Urban models generally operate by restricting land development in certain areas (and promoting it in others), depending on the existing land use characteristics, planning goals and socio-economic demand for development. The survey showed that transport/mobility infrastructure, heritage buildings and public spaces such as green space were the most commonly cited development restrictions (areas that cannot be developed). Conversely, transport accessibility, in terms of roads and public transport, as well as residential and non-residential building density were the land uses most commonly cited by urban models as attracting development.

When studying the responses provided regarding the development outcomes prioritised by urban models, the survey showed that the planning policies integrated into the models most frequently prioritise the strategic densification of existing built-up areas and areas close to public transport. Interestingly, there seemed to be less of a focus on developing "underused areas".

Looking at the developmental and operational aspects of urban models, the majority were developed using outside knowledge and resources – via a commercial product or through cooperation with consultancies or research institutions. In the majority of cases, respondents stated that staff at the authority in

question cannot augment or update the model. This indicates that urban planners who work "on the ground" for municipalities or regions often do not possess the expertise to operate such models..

While some enlightening answers were provided to questions regarding the attributes, basic features and development of urban models, more detailed questions on methodology and operational details appeared to be too detailed for most of the respondents. Also, the overall lack of response to the question about the costs associated with urban models shows that defining their actual costs is a difficult task. Rather than being one-dimensional, costs are often distributed across various budget lines, such as development, implementations, updating, consultancy costs, internal labour costs, etc.

The survey also indicated that internal knowledge and experience, high cost and data issues also act as barriers to the use of urban models by authorities.

The notion of collaboration and cooperation across municipal boundaries was also addressed in the survey. The results showed that, among the ten municipalities which stated they used models (the other six cases were regional authorities), only three models were developed completely independently. The other seven municipalities stated that the urban models were developed in some form of cooperation with other municipalities or their respective regional authorities. Therefore, the degree of cooperation appears not only to be quite positive, it also introduces the question of whether IUM projects could be seen as an opportunity to support new and strengthened forms of cooperation between municipalities and regional authorities. Furthermore, cooperation among and between authorities touches on what the most important objective of implementing IUMs ought to be – the provision of a tool to support decision-making that stimulates dialogue and debate among a broad group of stakeholders.

While 16 respondents stated that urban models have been applied in their area, 34 of the 50 respondents said they have not implemented an IUM. Some of the respondents in the latter group felt that their municipality or region is too small to justify the use of an IUM, the appropriate land use and transport data are too hard to access and/or the costs are unjustifiably high. However, the most common rationale that respondents provided for not using IUMs was that they were not familiar enough with IUMs and their benefits and do not have the technical skills to use them.

The survey's findings indicate that more and better information on the use and benefits of IUMs could be provided to planners and other related practitioners. This information should focus on how to integrate these tools into current practices as planning support systems and on the practical benefits of applying the models. Consequently, a more in-depth analysis involving those respondents who are in the process of applying or have successfully applied such models would make an important contribution to the IUM knowledge base. Not only would it be important to learn more about issues such as costs, data availability, learning and knowledge development, but it would also be valuable to learn more about exactly how the models are being used by planners; for what purposes, by whom and with what end goals or objectives in mind. This type of information provides insight into the expectations placed on the use of models that can provide newcomers with a better view of how they might benefit from these tools.

1 Introduction

1.1 Cities, environment and urban planning

Physically, cities are expanding faster than ever and, compared to rural areas, are increasingly responsible for the vast majority of national growth in developed countries. However, parallel to this growth, the spatial planning of city development is becoming increasingly complex – having to support growth opportunities while balancing the need to focus on important challenges such as demographic transformations, social problems and unrest, resource depletion, climate change management, transport congestion and underdeveloped mobility, and difficult trade-offs in land use decisions. Furthermore, these natural and human factors are highly interconnected, with dynamic feedbacks that require comprehensive approaches to understanding the challenges and opportunities for development.

Worldwide, cities are responsible for almost 75% of global resource consumption and contribute to a major proportion of the environmental impacts generated by the unsustainable production and consumption of resources (UNEP, 2011). Because of these impacts, cities are obvious targets for policies and actions that make genuine progress on environmental change (Bai, McAllister, Beaty, & Taylor, 2010). While part of this relates to the fact that decision-makers at municipal and regional levels have an increasingly large role in shaping economic growth strategies (Katz & Bradley, 2013), the reality is that cities and their administrations can act as leaders on multiple sustainability-related issues (Jensen, Christensen, & Hansson, 2011). Among the most important of these issues, municipalities often have the main capacity in two fields with important sustainability implications: land use and transport planning. Therefore, the tools used to support planners in their work with comprehensive policy and planning campaigns can play a crucial role in determining both the resource efficiency and attractiveness of urban areas (Jensen, Christensen, & Hansson, 2011). These tools include integrated land use-transport models – acting as planning support systems – which provide a better understanding of the future impacts of different planning policies, supported by knowledge about economic theories and social behaviours (Berglund, 2014).

This report presents the findings of a survey that was carried out by Nordregio between 14 November 2013 and 10 January 2014. The aim of the survey was to learn more about the use of integrated urban modelling tools by Nordic authorities through the following questions:

To what extent are integrated urban models being used by Nordic planning authorities?

What are the basic technical details of the models being used?

How are these models developed, implemented and used as planning support systems?

1.2 What are integrated urban models and why should we use them?

Integrated urban models (IUMs) combine multiple urban attributes to produce future land use development scenarios. These attributes revolve around the interplay between land use and transport development, and are processed in the model to propose optimal locations for future development. Attributes that may be included in an IUM:

- Residential buildings – location and density
- Population growth
- Non-residential buildings – location and density
- Job growth
- Roads
- Green space protection
- Public transport network
- Environmental risk management
- Cycling network
- Cultural heritage sites

These types of models have been developed over the past 65 years and have had many different names, e.g. land use models, integrated land use models, land use transport interaction (LUTi) models, integrated urban models, etc. We will proceed using the term "integrat-

ed urban models" (IUMs) in order to be as broad as possible and to acknowledge the highly-integrated nature of land use planning. A common feature of each of these models is that they, to differing degrees and through differing processes, integrate the land use/built environment and transport dimensions to provide an urban development scenario. This integration is based on the well-understood relationship between the development of the transport network and the development of the rest of the urban system, where "land use patterns influence travel needs, mobility patterns, and the evolution of transportation infrastructure; and the transportation system, in turn, influences where people engage in activities and how urban form changes." (EUNOIA, 2012, p. 9). In other words, land use and transport – as the location of things and the movement between them – are the essence of spatial patterns in cities.

Over the past 25 years, our understanding of how to plan cities has shifted, from top-down ordering and equilibrium to concern for local detail, complexity and change that is driven from the bottom-up (Batty, 2013a). This paradigm shift has been driven by two key factors: the incredible technological improvements in computing and geographic information technology and the impact of the "dissenting voices" of urbanists who have led us to an understanding that cities are complex, heterogeneous hubs of diversity, novelty and surprise (Batty, 2008).

Alongside this shift, urban growth has continued faster than ever, resulting in intense competition for space and ever increasing congestion. Planners therefore face the difficult task of dealing with the complex, interconnected and ever-changing context of urban development. They often struggle with the challenge of balancing the demands of growth with the desire to preserve the natural environment, unique community characteristics and other quality-of-life attributes. Planners rely on a number of different tools to help them accommodate the range of factors and considerations they face. Apart from IUMs, others include comprehensive and detailed plans, regional development plans, environmental impact assessments (EIA), strategic environmental assessments (SEA), life cycle analyses (LCA), ecological footprints, green accounting, multi-criteria assessment methods, indicator systems, frameworks, certification schemes and guidelines, all of which are developed for a range of single or multi-sectoral aspects of planning (Jensen & Elle, 2007).
IUMs help planners by:

- Providing a better understanding of the urban dynamic system.
- Highlighting the trade-offs implied in different urban development options in an integrated way by creating a simplified reality that can be manipulated through simulation.
- Enabling virtual experimentation that allows planners to test, demonstrate and evaluate the potential consequences of policy decisions and other actions on land use patterns (i.e. multiple simulations based on different development thresholds or planning strategies).
- Producing visual scenarios that can facilitate participatory, collaborative decision-making (in policy and design roles). The visual outputs provide a series of "what if" scenarios, dependant on the strategic policy decisions that are made.

Rather than being definitive statements about the future, these representations tend to narrow down the number of possible policy interventions without making a predictive statement about which is the only, or optimal, solution.

2 Nordic Survey on Integrated Urban Models

Few studies have focussed on the extent to which IUMs are used in practice and there is not one available that is set in a Nordic context. We therefore wanted to know where, how and why these models are being used in the Nordic region, or why they are not being used. While acquiring this information we also tried to get a sense of the opportunities for future use.

2.1 Method

Preparation of the survey involved a three-step process in order to ensure that it targeted the most relevant information about the development, implementation and use of IUMs in the Nordic countries. First, Nordregio prepared a draft version of the survey based on their existing expertise and a detailed literature and internet review of land use modelling. This was done using the online platform Google Drive, which was chosen because of its user flexibility and graphic qualities. Next, the draft was reviewed by the consultancy WSP Analysis and Strategy, who have a well-established history of developing and implementing integrated land use models. This review led to an iteration of the first draft, which was then sent to three municipalities during a pilot phase. This phase provided valuable feedback resulting in the survey being shortened and some of the questions being revised to produce the final version.

The survey was distributed to 140 municipalities and regional authorities in the Nordic countries on 10 November 2013. By 10 January 2014, a total of 50 responses had been received and representative coverage of the core city-regions was achieved by retrieving answers from at least one of the planning authorities (either the municipality or the regional authority) in each of the targeted regions.

The targeted planning authorities were selected by identifying the largest city-regions in the Nordic countries and their functional urban areas (FUAs) according to the OECD data and methodology (see Map 1). While the OECD data dates from 2006 (prior to the municipal reforms in Denmark and Finland), the new municipal structure was overlaid on the older version to ensure that all new corresponding municipalities and regions were covered in the survey. All core and hinterland municipalities in each city-region received the survey (see Map 1), as did each of the regional authorities.

The respondents at the municipalities and regional authorities who received the survey were identified in several ways. Some of the contacts were provided by their respective country's association of local authorities, while others were retrieved through individual internet searches. This resulted in a varied contact list that included head planners, Geographic Information System GIS experts and even the general inboxes of some planning departments.

Ideally, the hope was that those receiving the survey would forward it to their colleague who was best equipped to provide a response. However, it became clear that the questions were often too diverse (covering expertise held by multiple people rather than just one individual) to be answered by a single respondent and required additional information from multiple people. This is most likely due to the fact that questions addressed a conceptual, analytical and organisational space between GIS and urban planning and because in large organisations it is often multiple individuals who work with specific aspects of these fields. It thus turned out to be difficult for one respondent to provide a comprehensive overview of how tools were used in other departments.

Considerable effort was put into obtaining responses and following up on certain responses deemed particularly interesting or that required clarification. For instance, some respondents had indicated that they used IUMs, whereas it was subsequently made clear that the models used were of a simpler kind, usually based on more straightforward GIS spatial analysis. This divergence had an impact on the statistical results obtained from the survey and required us to make a distinction between those respondents who appear to be using "truly integrated urban models" and those who use some degree of modelling, but in what is probably a more simplistic and less integrated context. We

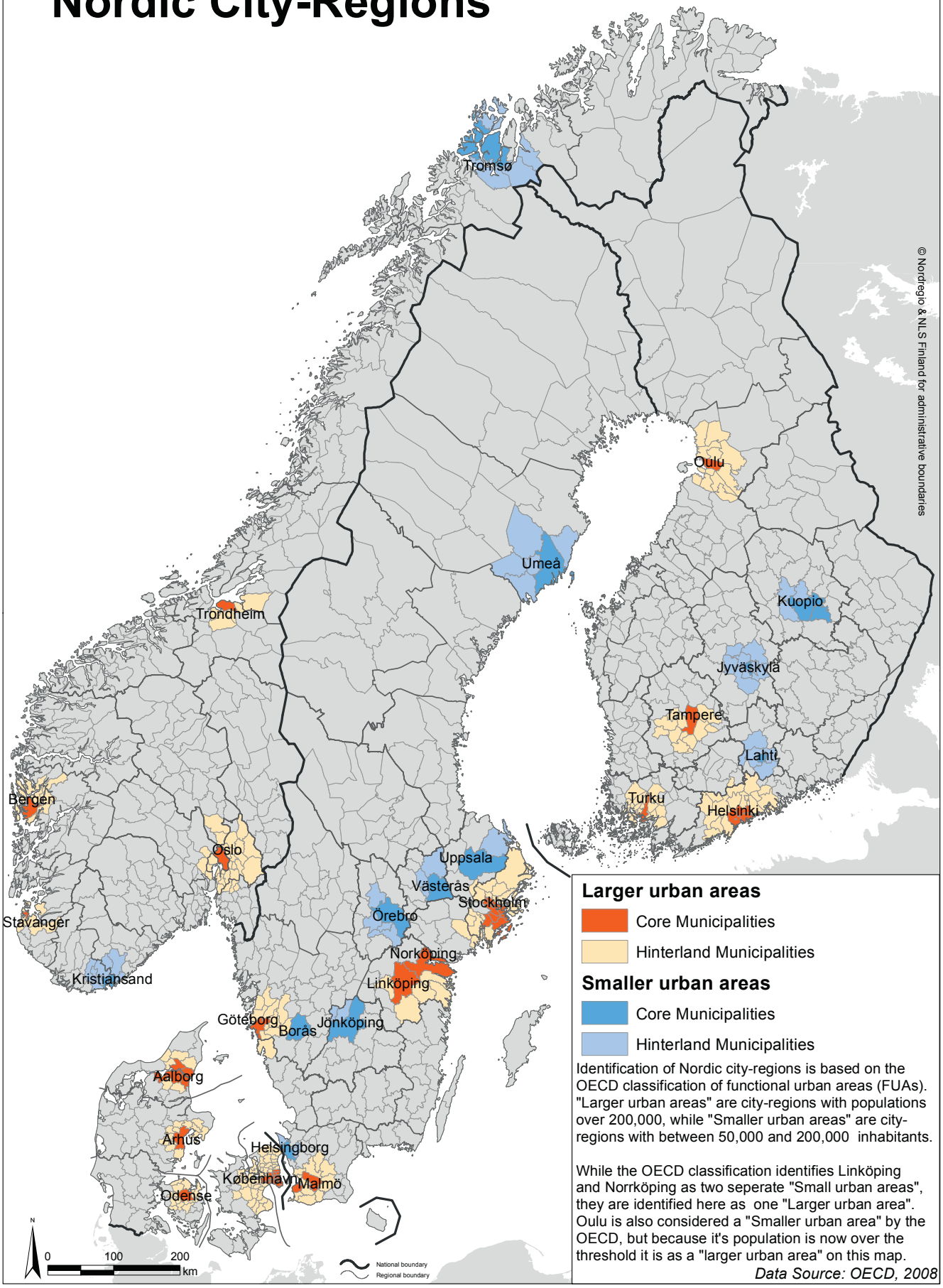
therefore decided to move forward on the understanding that, while those respondents reporting that they use IUMs in the first instance have adopted some sort of integrated approach to spatial development/physical planning, only a subset of these have gone as far to implement what we refer to as "*true* IUMs". While the survey identifies those cases where true IUMs appear to be used, the remainder of the analysis is based on the wider group of respondents who stated they use an IUM in the first instance.

We therefore make a distinction; the term "IUM" only refers to those cases where we think true IUMs are being used. We refer to all the other cases simply as "urban models" that consider land use in some kind of integrated way.

Lastly, while the responses do not provide a sufficient sample size to make definitive statements about the characteristics of IUM use in the Nordic countries, the 50 responses do provide insights from at least one of the planning authorities (either the municipality or the regional authority) in each of the targeted FUAs. Consequently, we can use the results to make indicative statements about potential IUM usage patterns in the Nordic countries. The results thus provide an interesting overview of the current situation and insight into the work that can be done to support more efficient use of models in the future.

Map 1: *Nordic city-regions targeted by the survey.*

Nordic City-Regions



Identification of Nordic city-regions is based on the OECD classification of functional urban areas (FUAs). "Larger urban areas" are city-regions with populations over 200,000, while "Smaller urban areas" are city-regions with between 50,000 and 200,000 inhabitants.

While the OECD classification identifies Linköping and Norrköping as two seperate "Small urban areas", they are identified here as one "Larger urban area". Oulu is also considered a "Smaller urban area" by the OECD, but because it's population is now over the threshold it is as a "larger urban area" on this map.

Data Source: OECD, 2008

2.2 General profile of the authorities that responded

We received 50 responses to the survey, providing the desired representative coverage of the largest city-regions in the Nordic countries we had targeted. Of these responses, 39 were from municipalities and 11 were from regional authorities. Twenty-two responses came from Sweden, twelve from Denmark, eight from Norway and seven from Finland. One response came from an Icelandic authority (within the Reykjavik city-region) and, even though this was not one of the targeted city-regions, it was decided to include this response to spread our coverage to an additional Nordic country.

One of the first questions concerned the size of the responding planning authority. Even though the survey focussed on larger FUAs, in practice these are comprised of upwards of 30 individual municipalities. As shown in Figure 1, over half of these municipalities have a population under 100,000. While these municipalities are not small in a Nordic context (for instance, only five Nordic city-regions have more than 500,000 inhabitants and only 12 have a population greater than 200,000), they could be considered as small in the context of the scale in which IUMs should be implemented. This was indicated in the report by Berglund (2014), which described how the use of IUMs tends to be most beneficial in larger city-regions, where there is most likely to be pressure on land resources and complex, integrated transport infrastructure.

Another question sought to establish the extent to which geographical information systems (GIS) are used by Nordic planning authorities, as this is required if municipalities or regions are to adopt the use of IUMs. In line with expectations, almost every region and municipality maintains a GIS database of land use and/or demographic data to aid them in strategic planning.

While the main focus of the survey was on integrated models, one question asked about the use of single models. This was based on the report by Berglund (2014), which identified three types of model systems that can be combined into modular model systems:

1. Single urban land use models, mainly used for planning purposes, as well as for policy analysis and assessment. Often detailed in terms of data and spatial resolution.
2. Single land use change models, mainly used in environmental sciences. Often detailed in terms of data and spatial resolution.
3. Land use and transportation models, which represent a holistic, systemic approach to urban and transportation systems. Often more generalised in terms of data and spatial resolution.

The last of the general profile questions thus asked about which urban issues are monitored and/or strategized using the first two types of "singular" models. Figure 2 shows that "Transport and Mobility", "Risks (e.g. flooding, etc.)" and noise are the dominant themes, while "Housing" was only identified by ten respondents.

2.3 The use of integrated models – diffusion in the Nordic countries

In the survey, we identified IUMs by saying that, "We view 'land use' as reflecting the development of the built environment, which is the urban space where people live, work, commute and recreate on an everyday basis. Therefore, land use models are technical tools for systematically analysing the impacts of policies, plans, projections, decisions, etc. on the built environment of urban areas. The notion of 'integrated' reflects models that combine multiple attributes of the

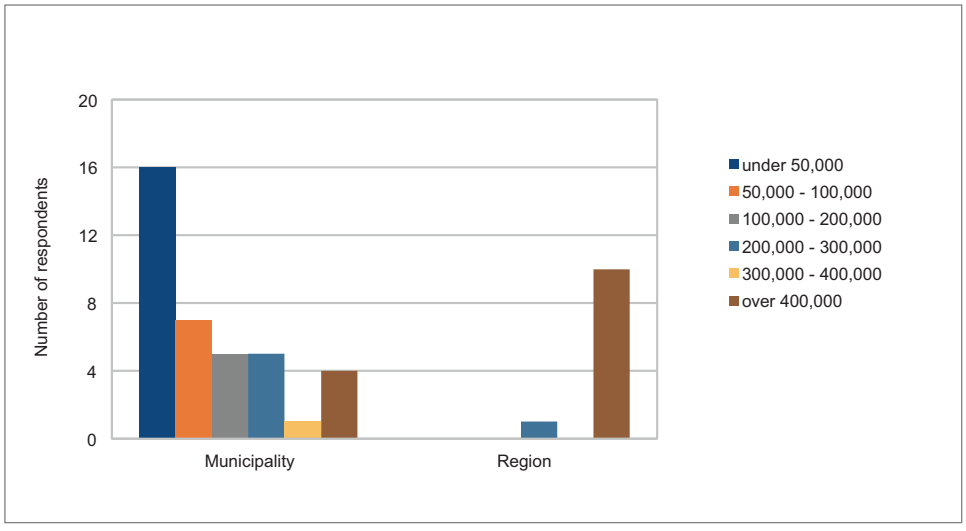


Figure 1: *Population distribution of the municipal and regional authorities that responded.*

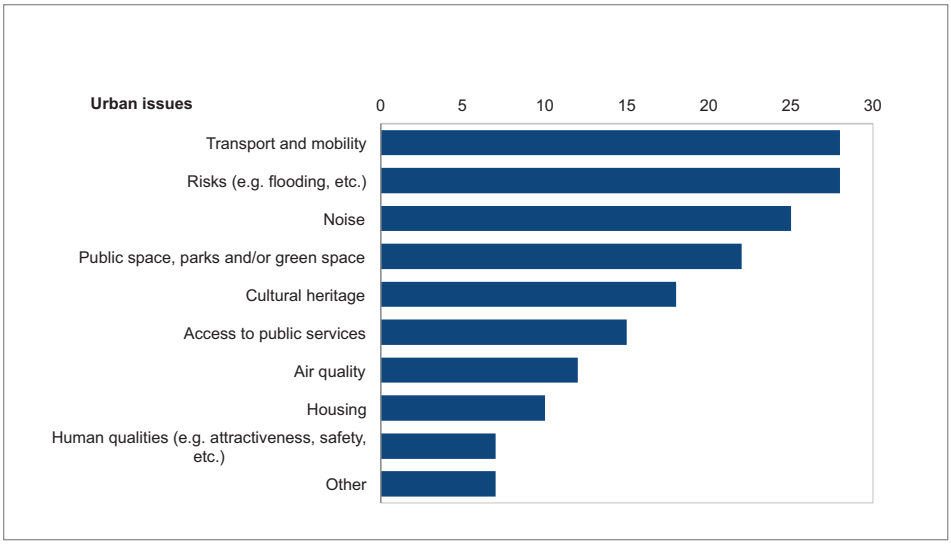


Figure 2: *Urban issues covered by modelling tools.*

built environment and socio-economic development as parameters, restrictions or potentials of the model (e.g. combining multi-mode transport accessibility with proximity to work space and preservation of green areas)."

It was surprising to note that 16 authorities initially stated that they use IUMs. From the results of the general profile questions, it is notable that:

- Eleven of the 15 municipalities with at least 100,000 residents stated that they use at least one IUM, while only two of the 23 municipalities with fewer than 100,000 residents said they use one.
- Eight of 27 municipalities (30%) with two or fewer transport modes in their public transport network stated that they use an IUM, whereas four of the nine cities with at least three public transport modes said they use an IUM. This roughly corresponds to Berglund's (2014) finding that integrating land use development with a complex and integrated transport infrastructure is an important rationale behind the use of integrated modelling.
- Two of ten authorities in Denmark, four of seven in Finland, five of eight in Norway and five of 21 in Sweden stated that they used IUMs. While there are a number of potential contributing factors that could explain these differences (not least the small sample size), the use of IUMs may be less prevalent in Denmark than the other Nordic countries.

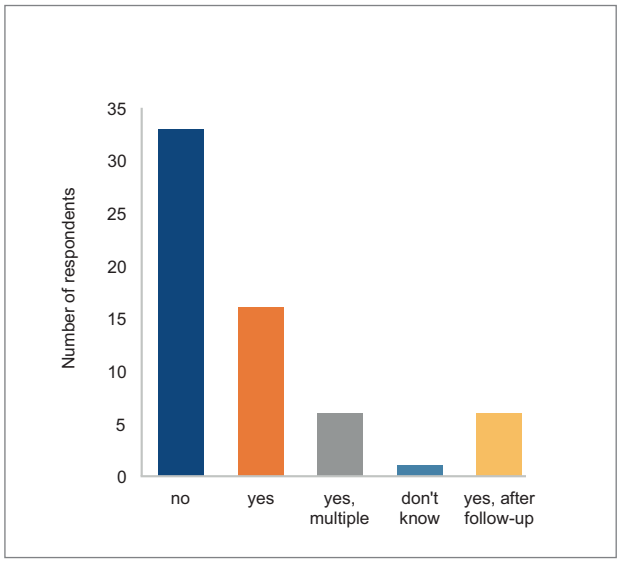
However, closer examination of the results showed that respondents did not have a consistent understanding of IUMs. For example, while some of the responses said that they do use integrated modelling, when asked the names of these models answers included: "ArcGIS analysis on planning and land use", "We use ArcGIS from ESRI... "and "We use GIS programs to integrate different types of information on maps, for example, public transport stops or flooding risks crossed with property databases. We use MapInfo for this". While many IUMs are largely constructed using GIS software, such as ArcGIS and its Spatial Analysis extension, the fact that respondents couldn't identify the names of the commercial or open-source models being used led to hesitation as to whether they are actually using IUMs.

In retrospect, it seems that our definition didn't do a good enough job of emphasising that we were referring to models that produce future land use development scenarios; and that there was confusion about the differences between single and integrated models. However, because IUMs are probably not widely used, it is also likely that there isn't a well-developed knowledge base on the characteristics, use and benefits of them in the Nordic countries (cf. Berglund, 2014).

As a result, follow-up clarification was carried out with most of the 16 respondents who originally stated that use/have used an IUM. We determined that six of the 16 respondents appear to be using an IUM that provides future development scenarios: two in each of Sweden, Finland and Norway. Three of these were municipalities and three were regional authorities.

As mentioned in the methodology, we therefore decided to proceed on the understanding that, while 16 regions/municipalities use some sort of integrated approach to spatial development/physical planning, only six of these have gone as far as to implement what we refer to as true IUMs. However, the remainder of the survey evaluates the use of "urban models" based on the 16 respondents who stated that they use these types of modelling tools.

Figure 3: *Use of IUMs by the responding authorities.*



2.3.1 Types of IUMs in use in the Nordic countries

Of the six respondents using IUMs, three separate models were identified. The following section offers some of their basic characteristics:

Integrated Planning Model (IPM):

The IPM was developed by the consultancy WSP Analysis & Strategy in 2006 and has been implemented by two regional authorities: Stockholm and Skåne. It is available free of charge, albeit with permission from the Stockholm County Council, and user support can be provided by WSP Sverige. It follows the cellular automata principles and is an ArcGIS-based land use model that provides detailed graphical output of future land use, with one of its strengths being the ability to handle densification of already built-up areas. Its main applications are in regional planning and future land use and it allows users to create and compare scenarios reflecting policy choices. It is modular software that is part of an integrated model system with the regional economic model rAps and the transport model LuTRANS/SAMPERS (Berglund, 2014).

Areal- og transportplanleggingsmodellen (ATP model):

The ATP model is a transportation and localisation model used in Norway. It was developed as a research project and is freely available. However, only the consultancy Asplan Viak has the ability to update and develop it further. Asplan Viak also provides analyses for municipalities or counties that prefer to contract out these services.

The model is based on the transport network taken from a national dataset, combined with local data about how people live and travel. It is used to measure distances and serves as an aid to locating new developments, schools or commercial areas, with the ability to use different scenarios to suggest the most effective location. While only two instances were found during the survey, further investigation revealed that it has been implemented in at least 13 different regions and municipalities in Norway (Skogstad Norddal, 2014).

YKR-aineistot:

YKR is the Finnish Monitoring System of Spatial Structure, developed by the Finnish Environment Institute, SYKE. It is a raster model (250x250 m resolution) that can analyse data about societal structure or local information about the number of inhabitants and workplaces, building density and car ownership. Responses to the survey showed it was used by the municipality of Oulu and the Varsinais-Suomi region.

2.3.2 Basic technical details of the models used in the Nordic region

The basic technical details of the urban models are their overall methodological frameworks, software requirements, spatial resolution and data input requirements. The findings showed that:

Questions were too detailed for most respondents:

The technical questions were too detailed for most of the respondents. In the rare cases an answer was provided, the respondents tended to be GIS experts rather than planners. This in itself is an important finding as it shows that applying an urban model typically requires contributions from a number of planning-related experts – experts who may rarely work in close collaboration with each other. In turn, this suggests the importance of good inter-departmental collaboration to facilitate urban model development.

Overall methodological framework:

Cellular automata (CA) models are clearly the most common, followed by a few respondents who noted that their urban models are based on equilibrium principles. As noted in the parallel report by WSP Analysis & Strategy (Berglund, 2014), this is interesting because, while CA is an important type of framework, it is by no means the only approach. In contrast, many simple yet effective IUMs use a rule-

based method that determines the future state of a land parcel based on strategic planning goals.

Software requirements:

Commercial GIS programmes, including ArcGIS and MapInfo, are clear standards, while open-source software and custom-built programmes within the models themselves are also used by a number of authorities.

Spatial resolution:

Equally-sized cells representing land use are the main spatial representation. These are likely to be at a fairly high scale – up to 100 metres resolution.

Data requirements and availability:

While seven of the respondents noted that the data was available free of charge, four noted that most of it is purchased from external providers and six mentioned that the data is available internally. Interestingly, of the four who stated that they purchase external data, three were users of the IPM and ATP models, which indicates that true IUMs likely require data to be purchased.

2.3.3 What land use attributes and policy priorities are considered?

Land use and socio-economic attributes are typically modelled through transition rules that determine where and to what extent urban development takes place. These rules restrict urban development in specific locations while prioritising it in others. A basic example would be selecting "protected green space" as a restriction (an area that cannot be developed) and vacant land next to a new train station as an opportunity (an area that can be developed up to a certain density threshold).

Figure 4 and Figure 5 show the attributes that are considered as restrictions or opportunities by different urban models. Restrictions based on mobility infrastructure, cultural heritage, public and green space, existing building densities and risks appear to be the most common.

As in the case of development restrictions, a majority of the identified urban models prioritise urban development according to transport accessibility (roads and public transport), existing and future demand for residential space and population development, public and green space provision and cycling infrastructure.

Thematically, the most common policy priorities emphasised by the identified urban models were: "strategic densification of existing built up areas" and "areas close to public transport". Interestingly, there appears to be less of a focus on developing underused areas. However, it is important to point out that, by running a model multiple times, planners can get visual representations of how different policy priorities could play out in space, thus providing planners and policymakers with more information with which to evaluate their options, which is an overarching and fundamental benefit of these types of models in general.

2.3.4 How are urban models developed, implemented and used?

Most of the models identified in the survey were developed with the help of external knowledge and resources, i.e. using a commercial product or through cooperation with consultancies or research institutions (Figure 7). Similarly, Figure 8 shows that, in the majority of cases, staff at the authorities in question rarely have the specific expertise required to augment or update the preferred urban model.

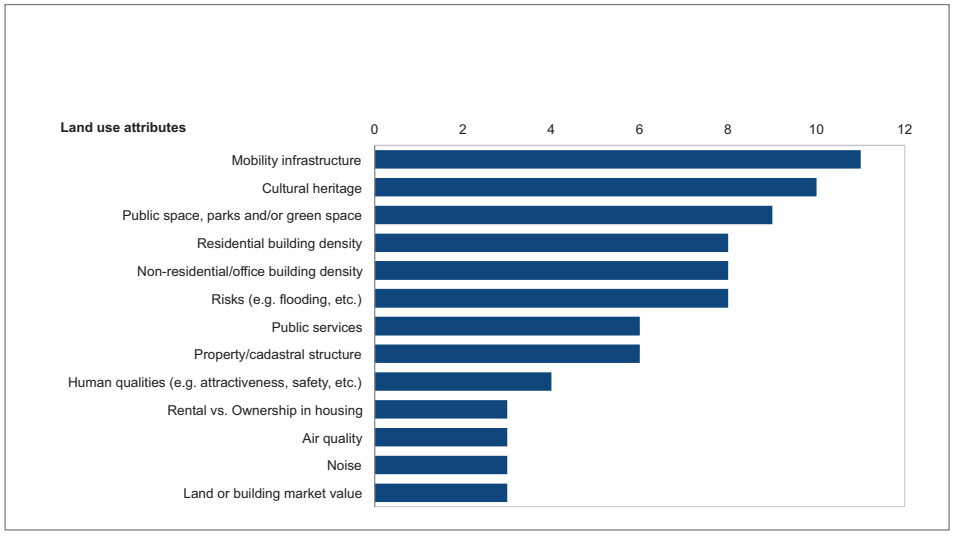


Figure 4: *Land use attributes considered as development restrictions by urban models.*

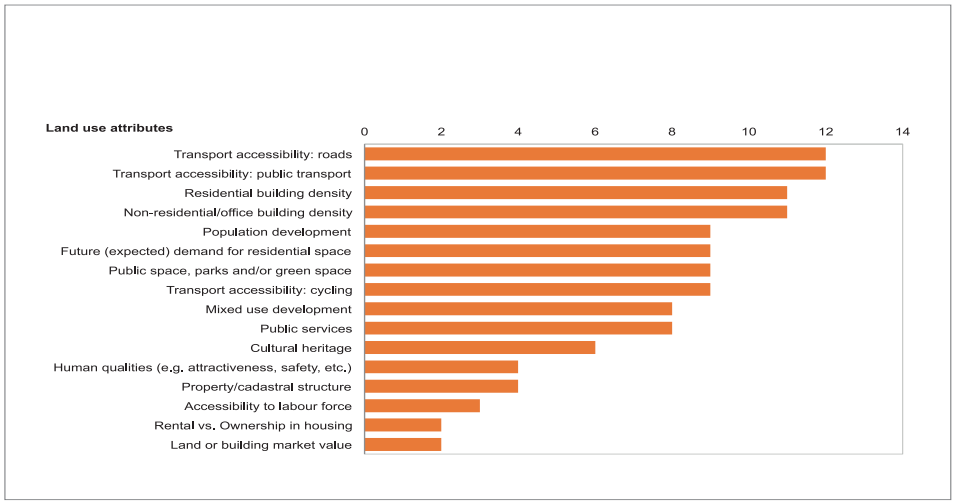


Figure 5: *Land use attributes considered as development opportunities by urban models.*

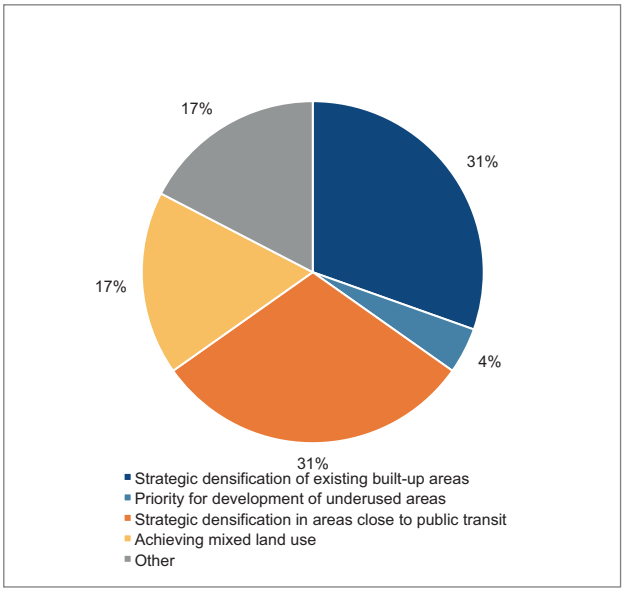
How models are used in a planning perspective is determined by the context and will vary considerably depending on how governance processes unfold in practice. Thus, it is a difficult question to answer using a survey. Nevertheless, Figure 9 shows that two thirds of the responses stated that their urban model is used to support strategic planning on an ongoing basis. This reflects the typical regenerative nature of strategic plans, which often go through circular processes of continuous development, implementation, re-formulation and updating.

Issues relating to cooperation, cost and constrains were also addressed in this section of the survey.

Cooperation among municipal authorities:

Sharing the development or use of an urban model could be due to a number of factors – it could help to reduce costs, it can help address the fact that municipal or regional boundaries do not reflect the way cities function or it could be that models have been developed by national governments for use at the regional or local level. Municipal respondents were therefore asked how their preferred model has been integrated with their neighbouring municipalities. Only four of 11 municipalities stated that they apply their model only to their municipal area (or parts of it). In contrast, three other municipalities noted that they apply their model in collaboration with neighbouring municipalities and three others share it with their respective regional authority. Not only does the degree of cooperation appear to be quite positive, it also introduces the question of whether IUM projects could be seen as an opportunity to support new forms of cooperation on urban spatial development issues.

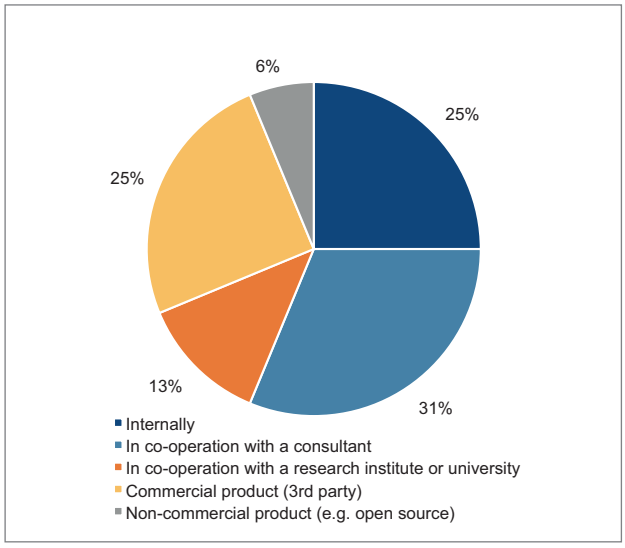
Figure 6: *Land use policy priorities emphasised by urban models.*



Cost:

The difficulty of accounting for the costs associated with developing and implementing urban models was emphasised by the overwhelming lack of responses to our questions on the issue. As suggested by Berglund (2014), costs can vary considerably. For instance, an open-source model is free, but there are costs associated with data collection, operating, training and maintenance, whereas models requiring the use of consultancies will have a completely difference cost structure. Only two respondents were able to provide an estimate of the cost, both users of the IPM model. One region said the cost of implementing the model was SEK 150,000, while the other said that it cost SEK 1.45 million to develop and implement; an illustration of the large variations in estimated costs.

Figure 7: *How was the preferred model developed?*



Constraints:

Seven respondents provided answers about the key constraints associated with the use of their preferred model. Two other respondents noted that their urban model is difficult to use, and the high cost of developing and/or running the model was also mentioned twice. Data constraints were also identified in four cases, including issues relating to accessibility, heavy data slowing down the model and difficulties updating data.

Figure 9: *How is the prefered model used by your authority?*

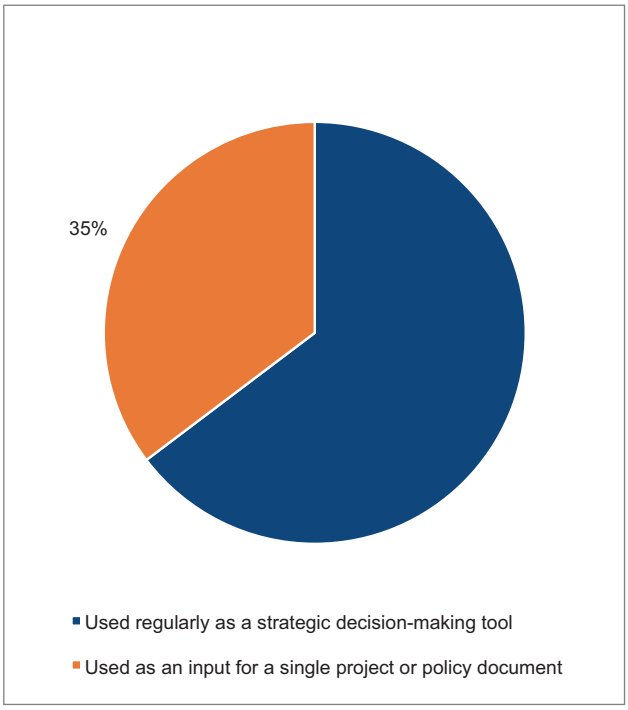
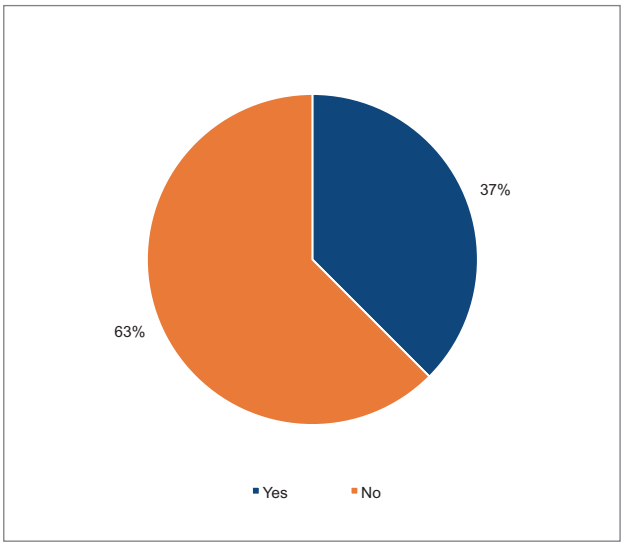


Figure 8: *Are staff in the authority's planning department able to augment or update the model?*



2.4 What about those authorities not using an integrated model?

The 34 respondents who stated that their authority does not use IUMs were asked an alternate set of questions. First, they were asked if they would consider using one in the future; 16 provided feedback, with seven saying yes, five maybe and four saying no. Some of the most interesting comments were:

- "Hard to say. We do not know the market for this kind of tool." "If the tools were more intuitive and easier to use, and if the data were more accessible and well-described."
- "Not at this time. It is often time-consuming to learn a new tool. The tools we use today are adequate for the small scale we work at. It's rare that issues are so complex we need modelling, and in those cases we do need it (for example, noise issues), we use consultants instead."
- "Our municipality has 2,400 inhabitants, and only one person working in the planning field, therefore, I am not sure we will consider using a land use model."

Each of the above comments reflects how the respective authority does not currently have the technical knowledge to develop or apply such a tool and that obtaining that knowledge might be too costly, relative to the perceived or expected benefits. In addition, two of the comments specifically note how their municipalities are too small and land issues are rarely complex enough to warrant the use of such models.

Another comment specifically referred to the cost of and bureaucratic process involved in investing in such tools:

■ "Yes, but it's been hard to convince the leadership of the administration."

But most interesting was the following comment:

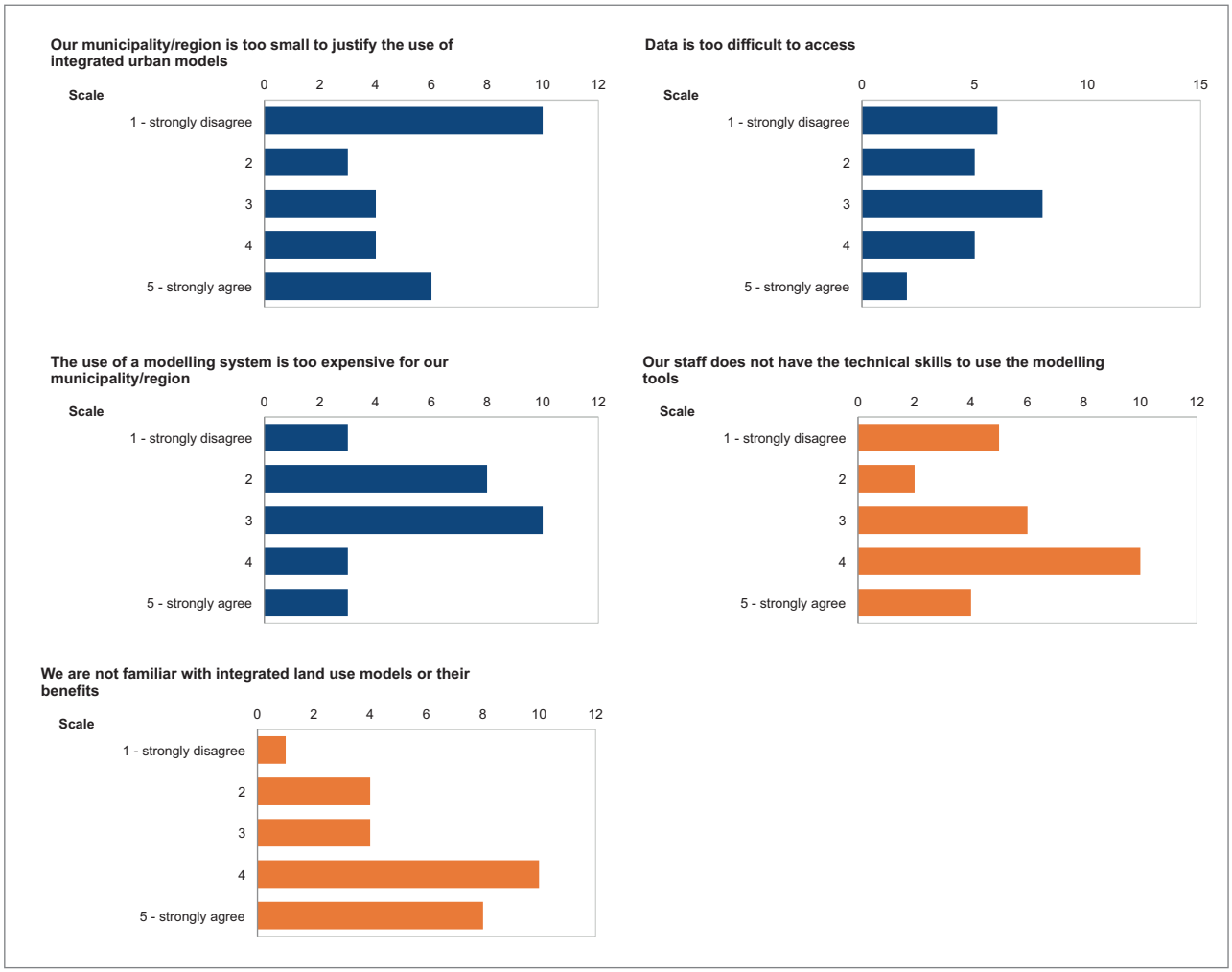
■ "Some years ago (2003), we developed a plan using operationalised goals for future expansion. The operationalised objectives were used to prioritise different land uses. GIS was an important tool. A model was built. The material was very interesting as a basis for discussion, but could not be used directly to produce a plan. We are not currently considering the future use of integrated modelling tools."

The last quote perhaps implies that the value of these types of IUMs can be misinterpreted, focusing solely on the production of part of an urban development plan. When this happens, the full merits of the tools (for supporting discussion and deliberation) may not be properly acknowledged.

Lastly, in an attempt to gain a better understanding of the reasons why they do not use IUMs, respondents were asked to rate, between 1 (strongly disagree) and 5 (strongly agree), how strongly they agreed with five statements about why their authority does not use IUMs. The results in Figure 10 allow for the following reflections:

■ On average, respondents disagree with the assertions "municipal size (too small)", "cost (too high)" and "data availability (too difficult)" more than they agree with them. However, the polarised responses to each statement (i.e. strongly agree or strongly disagree) show that these could be important reasons for some authorities. For example, we compared the responses with the size of the authority and found that those strongly agreeing with size being an important rationale were small mu-

Figure 10: *A series of questions asking respondents the extent to which they agree with statements regarding why IUMs are not used by their authority. Responses in blue represent an average response below three, i.e. an average disagreement with the statement. Responses in orange represent a response above three, i.e. an average agreement.*



nicipalities (most of them under 100,000 inhabitants), while those strongly disagreeing had a much larger population. Population size thus appears to be an important factor in determining whether models are used.

■ We quite clearly see that unfamiliarity with IUMs and their benefits and a lack of the technical skills to manage IUMs scored above the 3.0 threshold. This indicates that these are likely to be key factors limiting the use of such models.

In the last question in the survey, respondents were asked if they would like to be provided with a report synthesising the results of the survey. The high number of positive responses suggests that they would like more information about using models and that they find the information interesting and relevant to their work.

3 Conclusions

In relation to the general objectives of the survey, a number of conclusions can be drawn:

To what extent are IUMs being used by Nordic planning authorities?

- The survey results indicate that the use of IUMs is very limited. Although 16 respondents initially stated that they use IUMs, further analysis of their responses indicates that only six of the 50 respondents use/have used one of the three integrated models identified: IPM, YKR and the ATP model.
- Two of ten authorities in Denmark, four of seven in Finland, five of eight in Norway and five of 21 in Sweden stated that they used IUMs. While there are a number of potential contributing factors that could explain these differences (not least the small sample size), the use of IUMs may be less prevalent in Denmark than the other Nordic countries.
- In terms of those who responded that their authority does not use an IUM, Figure 10 showed that a lack of familiarity with IUMs and of the technical expertise to implement them seem to be the dominant factors limiting their wider use.

What are the basic technical details of the models being used?

- The general lack of consistency and the tendency for respondents to skip these questions is what initially made us aware that many planners in our target group are not familiar with the finer details of IUMs. The fact that respondents couldn't identify the names of the commercial or open-source models being used called their responses into question.
- While cellular automata (CA) models were identified as the most common methodological framework, they are by no means the only approach. In contrast, many simple, yet effective IUMs use a rule-based method that determines the future state of a land parcel based on strategic planning goals. These are probably the best option for planning authorities making an initial investment in IUMs (Berglund, 2014).
- The attributes identified as restrictions and opportunities in the models tell us a lot about what policies are being prioritised by planners. Development restrictions seem to be most commonly based on existing building densities, the location of mobility infrastructure, existing buildings/areas of cultural heritage and existing public and green space. Similarly, urban development appears to be promoted based primarily on transport accessibility (through roads, public transport and cycling infrastructure), population growth, future demand for residential space and building density thresholds. The core focus on building characteristics and mobility infrastructure seems to reflect the essence of the built environment, as the locations in the city and the way in which we move between these locations.
- Respondents identified most with the idea that they use models to promote strategic densification of existing built-up areas and areas close to public transport. However, it was interesting to note the comment by one of the respondents who stated that their model emphasises whichever development outcome is identified by a particular policy strategy. For example, by running a model multiple times, visual representations of how different development scenarios will play out in space can be obtained.

How are these models developed, implemented and used as planning support systems?

- The survey results supported the finding by Berglund (2014) that the costs of implementing an IUM can vary considerably depending on purchase, consultancy, training, implementation and maintenance costs – which in turn vary depending on for what and for how long the model will be used.
- External support from consultancies or research institutes appears to be common in the development of integrated models as urban planners working for municipalities or regions typically do not possess detailed knowledge of such models. This was also observed by Berglund (2014), who noted that a majority of IUMs are developed in academia and, if successful, are subsequently implemented in practice.
- Of the ten municipalities that mentioned they have used an urban model, only four stated that it was im-

plemented by their authority on its own. In contrast, six respondents mentioned that model development and/or implementation involved cooperation with other municipalities or some sort of shared approach with regional authorities. Therefore, the degree of cooperation not only appears to be quite positive, it also introduces the question of whether IUM projects could be seen as an opportunity to support new and strengthened forms of cooperation between municipalities and maybe even regional authorities.

4 Directions for future work

An underlying objective of this survey, together with the inventory of IUMs, was to identify a model that could be recommended for use in the Nordic countries – one that might enable a comprehensive, integrated approach to the modelling of urban development possibilities. However, the results of the project show, as expected, that only a few planning authorities currently use IUMs. In defence of this, it seems that there are some important barriers to the use of existing models, not least in terms of overall lack of knowledge about the implementation and benefits of IUMs. This identifies a knowledge gap within the planning community and between planners and researchers, which indicates the value of providing additional information, especially if the benefits of using these models can be effectively communicated. This could provide practitioners with the knowledge they need to make informed decisions about whether to invest in applying these tools to their work. This could include deeper analysis of issues such as costs, data availability and knowledge development. But it could also be valuable to learn more about exactly how the models are being used by planners; for what purposes, by whom and with what end goals or objectives in mind.

Much is currently being written on the need to improve the visual outputs of IUMs (cf. Serras, Bosredon, Herranz, & Batty, 2014) and the results of the survey also strongly encourage this. For IUMs to be successful, model developers must continue to respect an important design principle – that the outputs of the model should provide a basis for discussion among diverse groups of stakeholders about the long-term strategic development of city-regions.

Also, the lack of existing knowledge and use of IUMs indicates that a relatively simple, rule-based model would appear to be the most appropriate next step in widening the use of IUMs in the Nordic countries. In principle, these types of models would be relatively simple to implement and the rationales behind their findings are easier to comprehend and thus more likely to gain support within the Nordic planning community.

Lastly, the respondents showed significant interest in the theme of integrated models. Even though most of the respondents haven't used IUMs in practice (and many haven't been introduced to them at all), the vast majority are keen on learning more about the results of the survey. We also found that a small group of planners who have been working with IUMs in practice were more than willing to share their experiences in detail. Creating opportunities for them to share their experiences of these models could therefore lead to increased discussion concerning IUMs and their potential benefits.

As researchers, we certainly appreciated the fact that the majority of the respondents seemed to value the opportunity to reflect on processes within their organisation such as the lack of knowledge about what tools other departments were working with, the gap between planners and IT departments or even the lack of support from above for investments in these tools – despite requests. From this engagement with respondents we are able to see that the limited use of IUMs could also be a sign of poor integration between the sectoral policies of municipal and regional authorities. This poses the question of whether IUMs are not being used due to a lack of awareness, because they provide a poor representation of reality or because of a deeper lack of integration in urban spatial planning as a whole.

5 References

Bai, X., McAllister, R. R. J., Beaty, R. M., & Taylor, B. (2010). Urban policy and governance in a global environment: complex systems, scale mismatches and public participation. *Current Opinion in Environmental Sustainability*, 2(3), 129–135.

Batty, M. (2008). The Size, Scale, and Shape of Cities. *Science*, 319, 769–771.

Batty, M. (2013). *The New Science of Cities*. Boston: MIT Press.

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

EUNOIA. (2012). Urban models for transportation and spatial planning. EUNOIA Constortium.

Jensen, J. O., Christensen, T. H., & Hansson, K. G. (2011). Sustainable Urban Development - compact cities or consumer practices. Landinspektoeren. *Tidsskrift for Kortlaegning Og Arealforvaltning*., 46(1), 50–64.

Jensen, J. O., & Elle, M. (2007). Exploring the Use of Tools for Urban Sustainability in European Cities. *Indoor and Built Environment*, 16(3), 235–247.

Katz, B., & Bradley, J. (2013). *The Metropolitan Revolution: How Cities and Metros Are Fixing Our Broken Politics and Fragile Economy*. Washington D.C.: Brookings Institution Press.

Serras, J., Bosredon, M., Herranz, R., & Batty, M. (2014). Urban Planning and Big Data - Taking LUTi Models to the Next level? *Nordregio News*, (1).

UNEP. (2011). *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. A synthesis for policy makers*. United Nations Environment Programme.

ISSN 1403-2511
ISBN 978-91-87295-18-8

Nordregio
P.O. Box 1658
SE-111 86 Stockholm, Sweden
nordregio@nordregio.se
www.nordregio.se
www.norden.org

NORDREGIO
Nordic Centre for Spatial Development

norden
Nordic Council of Ministers