TEACHING MATERIAL GUIDANCE

1) Title of the material

Zhao, P.; Chapman, R.; Randal, E.; Howden-Chapman, P. Understanding Resilient Urban Futures: A Systemic Modelling Approach. Sustainability 2013, 5, 3202-3223. https://doi.org/10.3390/su5073202

https://www.mdpi.com/2071-1050/5/7/3202

2) Which section of the SUMP it is relevant to?

This article aims at introducing an urban model that can be used to evaluate city resilience outcomes under different policy scenarios. Therefore, the article can be linked to the third, fourth and fifth sections of the SUMP circle related respectively to the determination of planning framework, analysis of the mobility situation (in particular the analysis of problems and opportunities for all modes of transport - **subsection 3.2**.), scenario building and joint evaluation (development of scenarios of possible futures - **subsection 4.1**.) and vision and strategy development (arguments for stakeholders – **subsection 5.1**).

3) Which Mobility Manager knowledge this material is the most relevant to?

It is related to Transport and mobility planning (section 1 of the Mobility Manager competencies) especially 1b (employment of ITS/ICT and smart measures) and Data analysis for mobility planning (section 5 of the Mobility Manager competencies) especially 5a (data collection and analysis) as well as Stakeholder involvement tools (section 7 of the Mobility Manager competencies).

4) Problem approached and content overview

Problem approach – general understanding of how to manage the resilience of urban transport systems in smart cities. Cities' resilience in response to natural disasters and long-term climate change has become a focus of researchers and policy makers. In particular, understanding the interconnectedness of urban and natural systems is a key issue. This article presents an urban model that can be used to assess the outcomes of urban resilience in different policy scenarios. This model is the Wellington Integrated Land Use-Transport-Environment Model (WILUTE). It treats the city (i.e. Wellington) as a complex system characterised by interactions between various internal urban processes (social, economic, and physical) and the natural environment. It focuses on exploring the dynamic relationships between human activities (geographical distribution of housing and employment, infrastructure layout, traffic flow, and energy consumption), environmental effects (carbon emissions, impacts on local natural and ecological systems) and potential natural disasters (e.g. flooding from sea level rise and storms) that may occur under different policy scenarios. The model provides insights that are potentially useful for policies to strengthen the city's resilience by modelling outcomes such as the potential for reductions in transport energy use and changes in the vulnerability of the city's housing stock and transport system to sea-level rise.

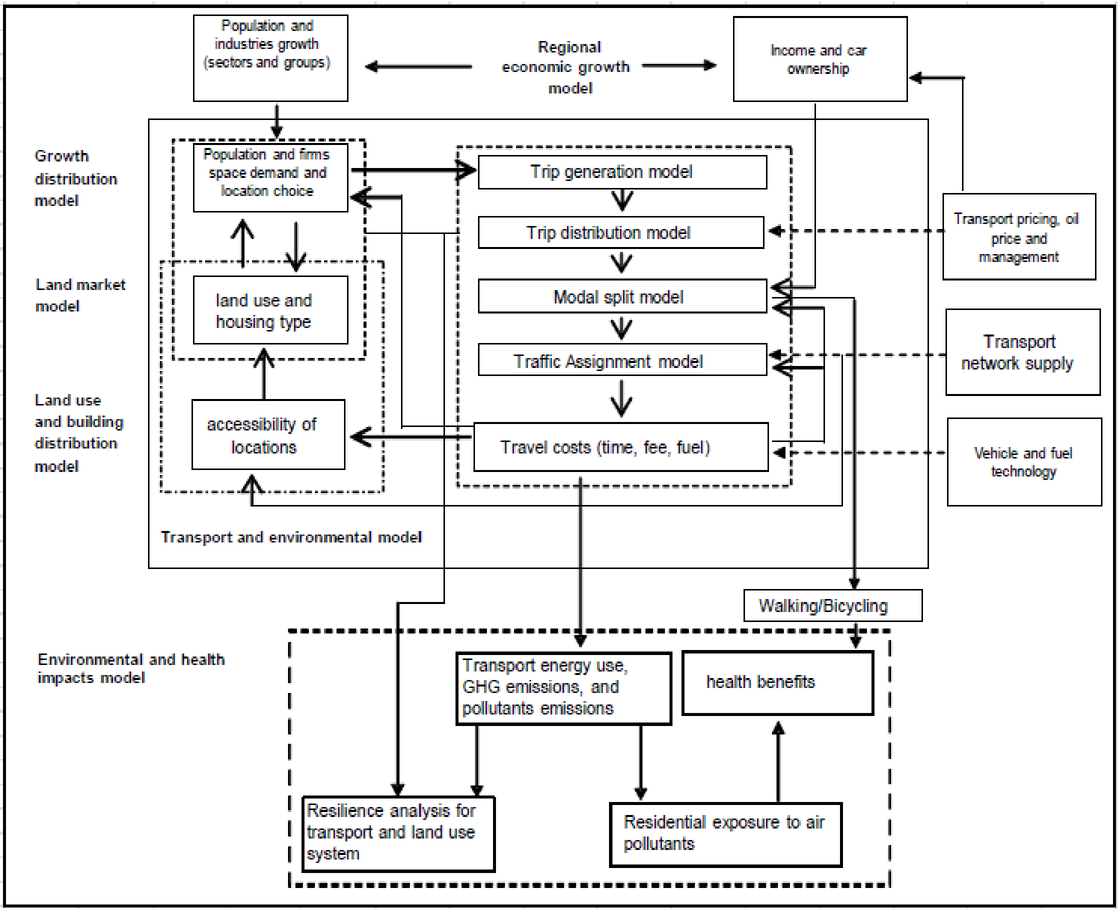

Figure 1. Architecture of the Wellington Integrated Land Use-Transport-Environment Model (WILUTE).

This paper presents an urban model that can be used to assess the outcomes of urban resilience in different policy scenarios. The model is the Wellington Integrated Land Use-Transport-Environment Model (WILUTE), which was developed by the New Zealand Centre for Sustainable Cities, University of Otago. This model was used to consider different policy scenarios and assess resilience. In the model, resilience is measured in three aspects. One is the city's ability to reduce energy consumption and greenhouse gas emissions, particularly as a result of changes in transport. The second is the sensitivity of the city's land use and transport system to sea level rise. Another is the costs associated with reducing vulnerability to a safe level, taking into account the city's financial capacity. If vulnerability and costs are too high relative to a city's financial capacity, its resilience is low. Wellington is the capital of New Zealand, which, like most coastal cities, is vulnerable to sea level rise, but resilient in terms of institutional, political, and human capacity. The Wellington-based model is useful for illustrating climate change mitigation and resilience policies for other medium-sized coastal cities in New Zealand and elsewhere. The WILUTE model considers the city as a complex system characterised by interactions between various internal urban processes (social, economic, and physical) and the environment. It focuses on exploring the dynamic relationships between human activities (geographical distribution of housing and employment, infrastructure layout, traffic flow, and energy consumption), environmental impacts (carbon emissions, impacts on local natural and ecological systems) and potential natural disasters (e.g. flooding from sea level rise and storms) to which the city is exposed under different policy scenarios. The model provides insights that are potentially useful for policies to increase the resilience of the city by modelling key outcomes such as traffic flows, energy use in transport, greenhouse gas emissions, distribution of homes and commercial areas, and transport links. These key modelling outcomes are the main drivers of changes in urban resilience, as indicated by the aspects described above (response to transport emissions, etc.).

5) Who could be interested in this material?

The article is aimed at students and those looking for inspiration in the implementations of models to evaluate and manage the resilience of urban transport systems when such measures are applied in SUMP.

6) What is worth mentioning as an innovative factor for the reader?

Making cities more resilient has become one of the most important goals of sustainable urban development in many countries. Planners, politicians, and the public are very interested in how to build a city that is resilient to climate change and other possible disasters. Researchers have made great efforts to contribute to the development of resilience policies, but there are still major gaps in the existing literature on urban resilience. In particular, a robust method for properly evaluating alternative resilience policies is lacking.

Policies for resilient cities are interpreted here as those that strengthen the capacity of the urban system to change in response to economic and natural shocks. Different urban systems built by humans and the natural system are complex. In particular, the complexity of urban systems poses a major challenge for identifying the environmental impacts of urban processes and assessing the effectiveness of policies to reduce environmental and health impacts. There has been considerable recent development of simulation tools for transport emissions and other health impacts. These approaches include operations research (OR), system dynamics (SD), and discrete event or discrete agent (DS) simulations. This study introduces an integrated land use, transport, and environment model that can be used to assess the resilience performance of a city under different policy scenarios. A city's resilience is measured by its ability to reduce energy consumption and GHG emissions, the sensitivity of its transport and land-use system to sea level rise, and the costs associated with reducing this sensitivity to a safe level, given its financial capacity. The model is designed to estimate the complex links between urban economic activity, choice of household and business location, transport, and land use, based on accepted urban system theories. The design of the model can extend our understanding of the system approach to the study of urban transport and land use policies and their impact on urban sustainability.

Future urban systems modelling still faces challenges, including the application of models in practice. The approach to treating 'dynamic' issues within a model needs further attention. Most models, including the WILUTE model, forecast the future state of the urban system and its environmental impacts regarding a base year. The future year is seen as the user-defined horizontal year for the model. The dynamic characteristics of the urban system are considered as the evolution of the system state from one point in time (base year) to another (e.g. horizon year). Many models assume that system equilibrium (within the land use system, the transport system, or both) can be achieved through the evolutionary process of the system.

In terms of policy practice, individual actions to build a resilient city or increase its resilience must be integrated; overall resilience is more than the sum of its parts. In the field of transport, transport infrastructure projects, urban planning, housing and travel demand policies should be integrated to reduce transport-related energy consumption and greenhouse gas emissions. A resilient urban policy should take into account different aspects of urban sustainability. In particular, environmental justice regarding different income and ethnic groups is often ignored. A resilient city will reduce its environmental footprint while improving the quality of life of its residents. Improving social and environmental justice is also one of the goals of building a resilient city. Integrated solutions, which can be explored through models such as the WILUTE model, must be considered in future policymaking to create resilient cities.

7) Limitations

The model presented here can simulate the dynamic processes of the system by invoking mathematical equilibrium conditions to represent the situation of the system at a given point in time. In reality, the dynamics of an urban system will be much more complex than we can simulate with such processes at different time intervals. For example, the WILUTE model assumes that there is a five-year time lag between land use and transport changes, and a five-year time lag is used to reflect such dynamics in the transport and land-use system. However, some fast dynamics in transport (e.g. departure time, travel route choice) may not be well-reflected. Some very slow dynamics (e.g. land use patterns in cities) may only be partially included in the time scale of the model. Combining different dynamic processes within one overall model is still a major challenge for the systems approach when it is used to assess urban sustainability. Secondly, the proper estimation of uncertainty in any urban system is another challenge for the development of such models. Uncertain interactions between urban processes and between human activities and environmental processes are typical features of an urban system. Urban system uncertainty is a constant topic of discussion in integrated modelling. How to increase the model's ability to respond to uncertainty in urban systems has become a new challenge for systems modelling. There are various possible ways to approach this issue. One is to increase the comprehensiveness of policy alternatives or scenarios. Another is to increase the flexibility of the model concerning the computational process and the data needed.